NORTHEASTERN FOREST EXPERIMENT STATION • FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE • UPPER DARBY, PA. • 1962

Annual Report

1961

1961 Annual Report

Northeastern Forest Experiment Station

•

Contents

In general..... 1
Forest management and fire research..... 3
Watershed management.....34
Forest insects.....41
Forest diseases.....50
Forest economics 61
Forest utilization.....69
Publications 77

NORTHEASTERN FOREST EXPERIMENT STATION • • 1962
RALPH W. MARQUIS, DIRECTOR

In General

OUR report for the calendar year 1961 returns to its customary format — a straightforward presentation of research studies and results. To maintain continuity in reporting, it includes activities and results for the year 1960.

Field Organization

Activities at two research centers — Laurel (Beltsville), Md., and Paul Smiths, N. Y. — were discontinued June 30, 1961. This action was taken to effect economies in the administration of our field units and to permit reassignment of personnel so that scientists working in different fields could be more closely associated with other workers in these fields.

No unfinished studies will be dropped. The Paul Smiths cooperative studies in forest management have been assumed by the Burlington (Vt.) Center; the cooperative wildlife habitat studies by the Warren (Pa.) Center; and the compartment studies by Paul Smiths College. The Beltsville studies in light and nutrition have been moved to Burlington, and the New Lisbon (N. J.) center is continuing the silvicultural studies.

Detection and appraisal surveys for insects and diseases are being transferred from the Experiment Stations to the Regional Offices. Region 7 has agreed to a 2- or 3-year transition period so that personnel transferred from the Station may be replaced as additional research funds become available.

Studies of the revegetation of mine banks have been extended into the anthracite region. All our studies in the bituminous and anthracite areas are now financed by cooperative grants. They are headquartered at Kingston, Pa.

A cooperative agreement has been made with the College of Forestry, State University of New York (Syracuse), for watershed-management studies. Arthur Eschner has transferred from Elkins, W. Va., to head up this work. In addition to carrying on research studies, Eschner will try to interest students in this field of study, because there is a current shortage of trained researchers in watershed management.

Frank Longwood has moved from Bangor, Maine, to Princeton, W. Va., where he will head up the new wood-products-market-development research project.

Other intra-station transfers are A. G. Snow from Beltsville to Burlington; Richard Fenton from Beltsville to New Lisbon, N. J.; Jesse Diller from Beltsville to Upper Darby; Frank Rushmore from Paul Smiths to Bangor; Clayton Carl from Paul Smiths to Burlington; Elwood Shafer from Kingston, Pa., to Warren; Robert Frank from Upper Darby to Kingston; John Staley from Upper Darby to Elkins; and Robert Wilson and Robert Peters from Upper Darby to the biometrics unit in New Haven. The purpose of these shifts has been to bring together men working in a common discipline or field of study.

New Construction

Funds were appropriated this year for the construction of two research facilities in the Northeast. One of these, at West Thornton, N. H., will provide office and laboratory space for our present personnel, and will get them out of the trailers that have served as headquarters for the watershed-management research program at Hubbard Brook. This construction is the first step toward what we hope will become a full-scale watershed-management research laboratory.

The other building will be constructed near Princeton, W. Va., to provide office, laboratory, exhibit, and meeting facilities for the new wood-products-market-development research center.

Facilitating Services

Several developments have taken place to provide better supporting service to our project workers and, directly or indirectly, better service to the users of our research results:

- A biometrics unit has been established in New Haven, Conn., in cooperation with Yale University. Its function is to advise research units on experimental design and data collection for electronic processing and to program and process these data. A program for forest-survey data has been prepared as a first study.
- A librarian has been employed to reorganize our central library in Upper Darby. Economy in operation and better service to headquarters and field units are the objectives.
- Our research publications, formerly processed at our own printing plant, are now being printed under commercial contract. And our system of distribution has been revised. Results are a much more rapid release of research results, higher morale for our authors, and a considerable saving in printing costs.

Forest Management and Fire Research

THIS year we are attempting to cover 2 years of activities for the Division of Forest Management and Fire Research. Since it would be neither possible nor appropriate to include the results and progress of each and every one of our 159 studies, we are, as in other years, featuring a few of the more important projects: light and nutrition, site, fire, recreation, and wildlife habitat. A number of studies in which substantial progress has been made are also covered in a special section titled Other Results.

In addition, there are several activities, initiated or expanded during the past 2 years, which can be described briefly as follows:

- The first draft of a new problem selection and problem analysis for genetics and tree-improvement work at the Station was completed recently. This report on the selection and analysis of genetics and tree-improvement problems in the Northeast is the first of its kind since 1937.
- Staff members of the Northeastern and Southeastern Forest Experiment Stations are cooperating on a revision of U.S.D.A. Miscellaneous Publication No. 693, *Timber Stand Improvement in the Southern Appalachian Region,* which appeared in 1949. The revised publication will be expanded to include new information and techniques, and it will include the northern as well as the southern Appalachians. Title for the new revised bulletin will probably be *Timber Stand Improvement in the Appalachian Region.*
- Ashbel F. Hough, of our Forest Management Research staff, is well on his way to completing a first draft for a U.S.D.A. bulletin on the *Silvics and Silviculture of Allegheny Hardwood-Hemlock Forests.* Hough, who has spent more than 30 years in research on the silviculture and management of forests on the Allegheny Plateau in Pennsylvania and New York, is exceptionally well qualified for this task.
- A new project in revegetation research and a survey plan for screen and cover planting sites was begun by the Station recently on coal mine banks in the Anthracite Region of Pennsylvania. Tree planting studies on strip-mine banks in the Bituminous Region are also continuing; this year two new studies are a clonal test

of hybrid poplars and a fall versus spring planting test of 15 tree and shrub species on the various types of banks. Projects in both the Anthracite and Bituminous Regions, headquartered at Kingston, Pa., are cooperative efforts between the Station and a number of educational, State, and private groups in Pennsylvania.

- A problem analysis for a silvicultural research project on hardwoods was completed recently by our New Lisbon Center. This project will include hardwoods in the Coastal Plain and Piedmont areas of Maryland, Delaware, Pennsylvania, New Jersey, and Connecticut.
- During the past year large-scale tests of an additional silvicultural system (even-aged) in hardwoods was begun as a compartment study on our Fernow Experimental Forest in West Virginia. The nine compartments of this study will complement the older and larger compartment study of selection systems (uneven-aged).

FOREST FIRE

In our Annual Report of 1958, we stated that, as our problem analysis on fire was reaching completion, research would be increased in 1959. However, for the past 2 years the Station has been without a project worker in fire research; so no real research has been accomplished during this period.

Two studies made in cooperation with Forest Service Region 7, and not reported previously did carry over into 1960. One study has to do with checking the reasonableness of certain entries on fire reports. When individual fire reports were analyzed for computation of rate of spread by fuel types and burning index, certain discrepancies in entries on the report form were noted. For example, one fire showed elapsed time from origin to attack as 1.5 hours, the perimeter increase as 3 chains per hour, and area when attacked as 4 acres. Obviously something is wrong with this report, because a 4-acre fire would have a minimum perimeter of 22 chains.

Since this type of error or discrepancy was fairly common and affected the accuracy of analyses made from these reports, it seemed necessary to develop some method whereby the person making out the fire report could check the reasonableness of certain entries on the form. So a simple table was devised to give the approximate number of acres in a fire when the duration or elapsed time and the rate of perimeter increase are known. Or, if the elapsed time and acreage burned are known and are thought to be accurate, but there is some doubt about the perimeter-increase figure, then an easy

check on the latter is possible. This table has already been made available to the people who report on fires.

The second study was a review of the rate of spread of fire and its resistance to control in the fuel types of the Northeast. Again the individual fire reports were used to supply data for the study. Results of this investigation showed that there are four logical groupings of fuel types in the Northeast in respect to rate of spread; these are: *low* (less than 30 chains per hour in perimeter increase), *medium* (30 to 40 chains), *high* (40 to 48 chains), and *extreme* (48 + chains).

This study also points up an interesting statistic as related to the relative difficulty of constructing and holding a control line as affected by difficulty in line construction and by fire behavior. In comparing the average rate of held fire line constructed per man-hour for the different periods of time, it was found that the average rate for the 1950-58 period was less than for the 1930-41 period. This difference is thought to be due to the increasing unwillingness of fire fighters to perform hard physical labor today as compared to 25 years ago. So there is added incentive for going over more and more to building fire lines with machines.

During the next year we hope to have one or two project workers on fire research. Several of the highest priority problems that should be studied have to do with suppression organizations, fire-damage appraisals, fuel types as related to fire danger, determining the basic reasons why large fires (over 100 acres) occur, and improved strategy, techniques, and equipment for fighting fires.

FOREST RECREATION

Now that the second year of research in forest recreation at our Warren Research Center has drawn to a close, it is fitting that we pause long enough to take a look at the progress made so far and the direction in which the program will go in the future.

The early studies have dealt with user preferences and methods of measuring these preferences, and with identifying the attitudes and responses of the forest recreationist. In the future these types of studies will be expanded, and more attention will be given to such problems as the coordination of recreation with other forest land uses, the impact of new public recreation developments on surrounding communities, opportunities in privately-owned recreation areas, and the question of use fees on public and private recreation facilities.

A picnic area in the Pocono Mountains of Pennsylvania. By mapping the frequency with which facilities are used, researchers can determine whether picnickers prefer to be near the road or back in the woods, on grassy areas or under trees.

Studies conducted during the past 2 years are beginning to yield results, some of which have been of immediate use to recreation administrators, and others that have been useful in formulating a research program and are basic to the conduct of more complex and comprehensive studies. Publications are or soon will be available on most of the more promising studies reported below.

Mapping Use of Facilities

In an attempt to determine what people want in the way of recreational facilities, we mapped the frequency at which different locations and types of facilities were chosen by visitors. This study, begun in 1960, was made at Chapman State Park in Pennsylvania and South Pond Recreation Area on the White Mountain National Forest in New Hampshire. Analysis showed that the number of trees, type of ground cover, and presence of overhead tree cover probably has something to do with the locations and facilities people use. This study was expanded in the summer of 1961 to examine visitor preferences for campsites on eight unsupervised campgrounds on the White Mountain National Forest.

As an example of how administrators can use this use-mapping, consider the location of picnic tables. The maps showed a definite preference for picnic tables close to parking areas. In general, people

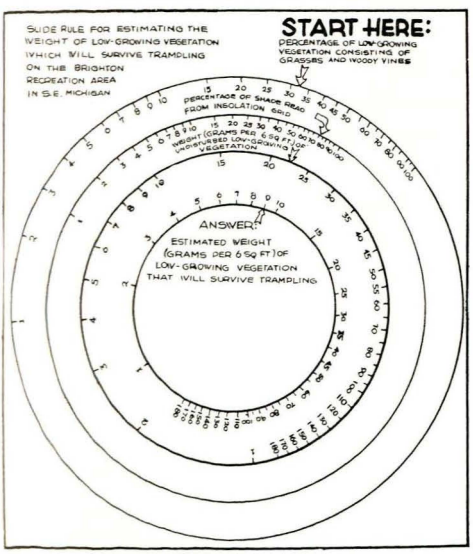
used picnic tables that were within 250 feet of parking areas. Even when the area was extremely crowded, tables beyond 400 feet from parking areas were not used. Although to a forester 400 feet may seem close to the road, to a picnicker it seems way, way out in the woods.

Durability of Vegetation

The durability of low-growing vegetation on recreation areas depends on several site and vegetation conditions. Although the exact relationships have been difficult to evaluate, a relatively simple method has been developed that permits a fairly accurate estimation of the durability of vegetation under trampling. Tested on the Brighton Recreation Area in southeastern Michigan, this method was developed from a dissertation study by J. A. Wagar at the University of Michigan.

Durability, in terms of the weight of low-growing vegetation that survived trampling, was first related to (1) the amount of vegetation present, (2) amount of shade present, and (3) proportion of ground vegetation that is composed of grasses. Then this information was adapted to a circular slide rule that the recreation administrator can use to predict how heavy the vegetative ground cover will have to be to survive trampling by recreational users.

"TRAMPLING" SLIDE RULE


SLIDE RULE FOR ESTIMATING THE WEIGHT OF LOW-GROWING VEGETATION WHICH WILL SURVIVE TRAMPLING ON THE BRIGHTON RECREATION AREA IN S.E. MICHIGAN
START HERE:
PERCENTAGE OF LOW-GROWING VEGETATION CONSISTING OF GRASSES AND WOODY VINES
PERCENTAGE OF SHADE FROM INSOLATION GRID
WEIGHT (GRAMS PER 6 SQ FT) OF UNDISTURBED LOW-GROWING VEGETATION
ANSWER:
ESTIMATED WEIGHT (GRAMS PER 6 SQ FT) OF LOW-GROWING VEGETATION THAT WILL SURVIVE TRAMPLING

A slide rule devised for estimating the weight (durability) of low-growing vegetation, and how it will survive trampling by recreationists.

Solving a Pit-Toilet Problem

In an upwind approach to a common problem on recreation areas, the Station has developed a device to reduce the offensive odors from pit toilets. The device, a flame-actuated convection stack, has a kerosene burner that creates a draft in a stack leading from the pit up and out through the roof.

The burner sets up a circulation that draws fresh air into the building, down into the pit, and up through the stack, carrying the odorous gases out, some of which are consumed by oxidation as they pass the burner. Tested on a recreation area, the device proved to be quite effective; and the burners require very little maintenance.

Sampling Campground Use

In response to a request from the White Mountain National Forest, the Station undertook to devise a sampling system for estimating the number of people who use unsupervised campgrounds. A study was made last summer in which visitors were counted on several campgrounds each evening during the entire summer.

The results of the study make it possible to estimate the total use on all unsupervised campgrounds for the entire season, from a relatively small sample and with good accuracy (within 3.8 percent of the true figure, and with a probability of 19 out of 20 times).

Attitudes of Recreationists

Very little is known about the people who use forest recreational facilities—who they are, what they want. So, late in the summer of 1960, visitors to recreation areas on the Allegheny National Forest in Pennsylvania and the Monongahela National Forest in West Virginia were asked to fill in questionnaires to provide such information.

Preliminary analysis of their responses has shown that factors such as distance from home, education, health, occupation, income, age, and sex are related in significant ways to their recreation activities, desires, and attitudes. Analysis of these data is continuing. Such information should be useful to administrators in predicting the needs and desires of the public and in planning recreational areas and facilities for serving these needs and desires.

A Plan for Washington County, Maine

Washington County, Maine is one of those areas that produce large quantities of valuable wood products and game from

its plentiful forests. However, another valuable product of these forests—recreation—has scarcely been tapped except perhaps for hunting and fishing.

At the request of and in cooperation with several state and local government agencies, private industry, and citizens' groups, the Station is preparing an analysis and plan for the development of the forest recreation resource in Washington County.

The purpose of this plan is to provide guide lines for retaining essential landscape values, and at the same time obtaining an orderly development of the recreation industry as a stable and significant portion of the county's economy. Collection of field data was begun in the summer of 1961, and completion of the analysis and plan is scheduled for 1962.

Irvine Demonstration Area

Although the 589-acre Irvine Demonstration Forest Area on the Allegheny National Forest was set aside for recreational use in 1959, and our Warren Research Center was charged with its administration, it was not until 1961 that plans began to materialize.

Recreation use on the 10-unit campground began in the middle of May 1961 and continued past the middle of November. At times as many as 55 camping parties occupied the area. Now a new 48-unit campground is being designed that, in addition to providing camping facilities, will also provide research results.

High water had seriously undermined portions of the Allegheny River bank bordering the recreational area. This was repaired by laying rip-rap reinforcement. The old mansion was recently torn down and a picnic area is being planned for the ground it occupied.

A nature trail has been laid out in the recreation area, and an educational program is being planned for interpreting its natural features for the visitor. The outstanding Simpson collection of mounted birds and animals, recently received, will be useful in interpreting wildlife habitat to the public. Plans are also being readied for demonstrating the various elements of multiple-use forestry here.

WILDLIFE HABITAT

As in recreation research, the second year of our program in wildlife habitat is also drawing to a close. Much work has gone into a selection of problems, problem analyses, and literature review during the past 2 years. One facet of the wildlife program that has received special attention is deer browsing. This subject has been thoroughly

analyzed, and as a result of this analysis four studies have been or are being conducted, and at least nine other problems are recognized as requiring additional major research effort. These problems are:

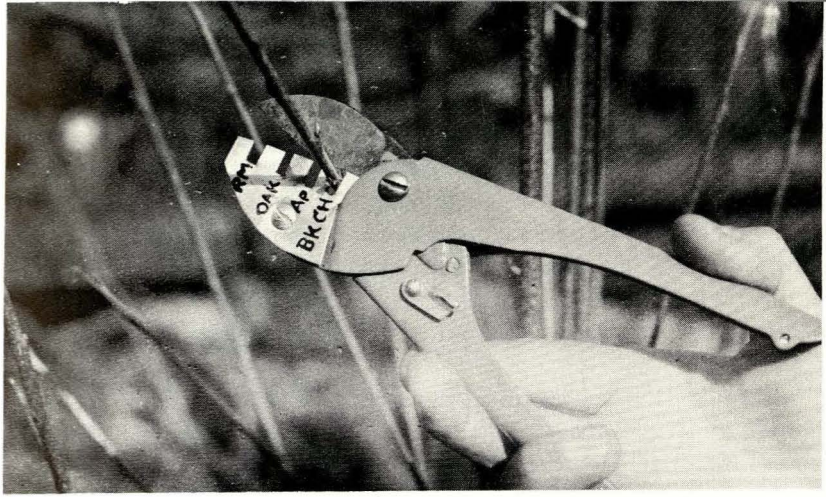
- The development of browse-measurement techniques that are quick and easy to use but sufficiently accurate for management purposes.
- Effects of timber stand treatments and cutting levels on browse production and utilization, and on timber growth and quality.
- Systems of coppice management and their long-term effects on browse production, length of cutting cycle, and timber quality.
- Adaptation of noncommercial browse-production techniques to sustained timber production methods.
- The net effect of balanced deer-carrying capacity on wildlife populations other than deer.
- Effectiveness of extending winter deer ranges by underplanting coniferous species in young hardwood stands that have been thinned for browse production.
- Use of fertilizers for increasing nutrient content of undesirable understory reproduction.
- Effect of browsing intensities on nutrient content and future growth of various browse species.
- Coordination of deer browsing with timber growing and with other uses of the land.

While habitat problems of other wildlife species in the Northeast have been recognized and plans are being made for their study, the problems with deer are so widespread and important that it seems only logical that we concentrate most of the efforts of our 1½-man staff on deer problems—at least for the present.

The two most important aspects of the deer-browse problems listed above that need urgent attention are the development of browse-measurement techniques and the coordination of deer browsing with timber growing and with other uses of the land.

Methods for Measuring Browse

In the spring of 1960, a study was conducted in a 2-year-old hardwood sprout stand in northeastern Pennsylvania to evaluate and refine a twig-count method and to compare this method with two other methods of measuring browse. The other two methods are a direct weight-estimate and clipping and weighing. Browse values for all three methods were expressed in pounds per acre, which required converting twig-counts to pounds.



The clipping template used in studies of browse growth. The slotted openings indicate the maximum browsing diameters for red maple (RM), oak, aspen (AP), and black cherry (BK CH).

The clip-and-weigh method, using a clipping template, was the standard to which the other two methods were referenced. Four observers used the twig-count and weight-estimation methods and one of the four also used the clip-and-weigh method on five species of hardwoods: red maple, red oak, quaking aspen, black cherry, and white ash.

There were no significant differences in the results among the three methods in determining weight of browse, but there were differences in the amount of time involved for the three methods. The average time required for each 100-square-foot plot was: weight estimation—3.2 minutes; twig count—4.6 minutes; and clip and weigh—21.8 minutes.

Thus the twig-count method is nearly as fast as the weight-estimate method and just as accurate as the clipping and weighing. Also, the twig-count method gives results that can be analyzed statistically and can be used for measuring both browse production and utilization on permanent sample plots.

Cutting for Browse and Timber

In 1961, a dual-use study of cutting intensities for the production of browse and timber in young northern hardwood stands was established on Pennsylvania State Game Lands near Brady's Lake in northeastern Pennsylvania. This is a cooperative study by the Pennsylvania Game Commission and the Station.

The primary objective of this study is to compare the effects of six widely different cutting intensities on annual and total browse production and utilization—including average browsing diameters and twig weights during the first 5-year period after treatment. The secondary objective is to compare the effect of cutting intensities on: (1) growth and quality of residual timber, and (2) sprout and seedling reproduction at the end of the first 10 and 20 years after treatment.

Several of the six cutting intensities resemble, in part, cuttings that are sometimes made on game lands for the purpose of increasing browse material. However, to the extent possible, the treatments in this study were planned to include good thinning and improvement cutting methods from the standpoint of the timber manager. The cutting levels resulted in residual basal areas of 0, 15, 30, 45, and 60 square feet plus a control with no cutting.

As this study progresses, it is hoped that it will have increasing research and demonstration value toward effecting the coordination of deer and timber management on the same land.

Other Wildlife Habitat Studies

Two other minor studies are being conducted in wildlife habitat. One is in cooperation with silviculturists in a preliminary effort to separate the silvicultural effects of clear-cutting in strips from those of deer browsing as both influence the reproduction of Allegheny hardwoods. Early results indicate that, while deer browsing may seriously reduce stocking and height growth of important hardwoods on low- to medium-quality sites, the damage on high-quality sites is usually much less severe and less permanent.

The other study is one of observing the response of seedlings of selected hardwood species to simulated intensities of deer browsing. Treatment effects on survival, height, form, and browse production will be observed and measured over the next 5 years with the objective of developing browse-utilization factors for seedlings of important commercial species.

SOME RESPONSES OF TREE SEEDS AND SEEDLINGS TO LIGHT

Before our Laurel Research Center was closed out in 1961, considerable work had been done there on the influence of light upon seed germination and seedling growth. Some of the studies also included nutrient level of the soil as a second variable. Although

two reports have been issued on certain specific aspects of this work[1], and a few paragraphs have appeared in previous annual reports, results of the research as a whole have not been published. The intent in this short report is to give some highlights from each of the several types of studies that were done.

Seed Dormancy and Light

The whys and wherefores of tree-seedling behavior in the woods and in the forest tree nursery have challenged every serious thinking forester at some time or other. During the past two decades, in particular, researchers have dug progressively deeper to find some of the answers—and they have made significant progress on many fronts. But they still have a long way to go.

One important part of the biological environment is light. Early observers noted that the light requirements of seedlings of different tree species vary, and further, that the requirements vary with seedling age.

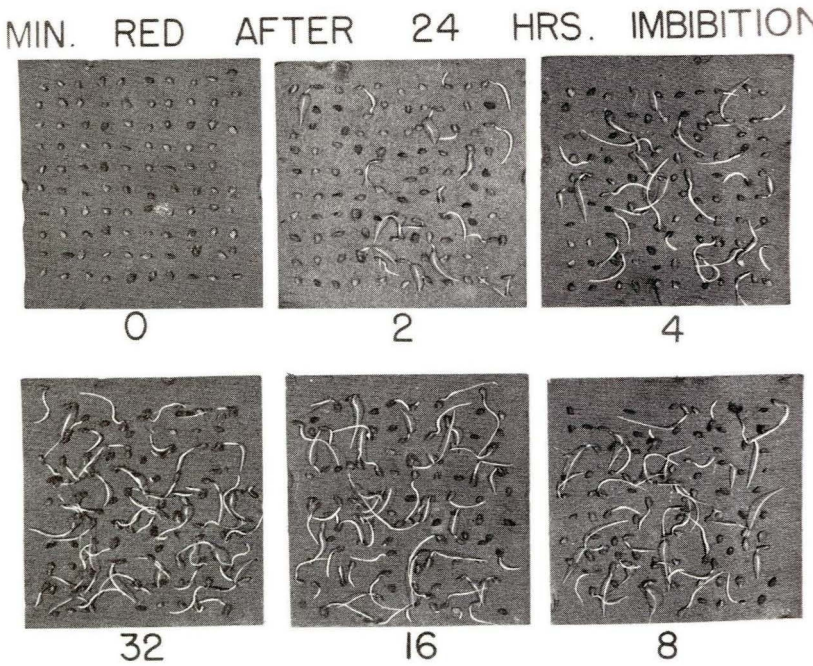
Much later, it was discovered that light influences the breaking of dormancy in some kinds of seed. Only recently have we begun to learn some specific facts about the relationships that are involved. At the Laurel Center we worked in cooperation with the Agricultural Research Service Seed Investigation Laboratory at Beltsville, Md., in studies of the effects of light upon germination of several kinds of pine seed. The red end of the spectrum seems to play the major role. Such basic findings give us hints on how we may increase the efficiency of seed handling.

Moist seed stratification at low temperatures to break dormancy —often a cumbersome operation with bulk seed—may be replaced by streamlined light-treatment methods as a result of further research in this field. As an indication of the possibilities along this line, germination of unstratified Virginia pine seed in one of our cooperative studies was increased from 5 percent (no light) to 92 percent by 1 hour's exposure to red light. The only pretreatment was to allow the seed to imbibe moisture on wet blotters for 28 hours in the dark. Seeds germinated best when imbibed at 5 °C. After the conditioning treatment with red light, the seed were returned to the dark. The best germination occurred at 25 °C.

---

[1]Hacskaylo, Edward, and Snow, Albert G., Jr. Relation of soil nutrients and light to prevalence of mycorrhizae on pine seedlings. Northeast. Forest Expt. Sta., Sta. Paper 125. 13 pp., illus., 1959.

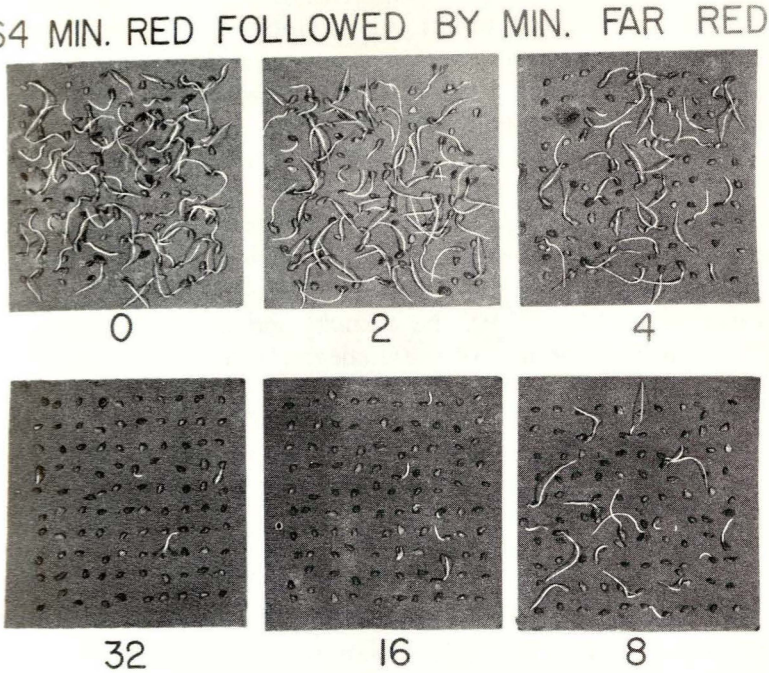
Toole, Vivian K., Toole, E. H., Hendricks, S. B., Borthwick, H. A., and Snow, A. G., Jr. Responses of seeds of *Pinus virginiana* to light. Plant Physiol. 36: 285-290, 1961.



Germination of Virginia pine seed can be increased by exposure to light. The red end of the spectrum seems to play the major role in breaking seed dormancy. Figures indicate minutes of exposure to red light. Light treatment followed 24 hours of imbibition.

The general problem of tree seed dormancy of course was not solved by this preliminary research on Virginia pine. We soon found that loblolly and white pine seed required different handling —particularly a longer exposure to moist, cold conditions to induce waking up. Also, we found that some pine species could be put to sleep again by further exposure to far-red light (wavelength 6950 to 7900 A°) immediately after having been promoted by red light (wavelength 5800 to 6950 A°).

These results, though they by no means complete our understanding of all the basic factors of seed dormancy in relation to light, temperature, and moisture, do point to ways in which this knowledge ultimately might be supplemented and used in a practical way. Direct-seeding attempts have often failed—due in some cases possibly to a state of dormancy not overcome by field conditions at the time of sowing the seed. Pretreatments with proper light, moisture, and temperature regimes might increase successes in direct seeding.



After seed dormancy has been broken by exposure to red light, the seed of Virginia pine can be put back to sleep again by further exposure to far-red light. Figures indicate minutes of exposure to far-red light. All seeds were pretreated with red light for 64 minutes.

Also, similar pretreatments might well shorten, simplify, or eliminate stratification requirements with some species, speed up subsequent controlled-breeding cycles, reduce losses in high-value seed produced in hybridization research, and decrease the amount of seed required in nurseries because of higher germination levels.

Photoperiodic Ecotypes

Ideally, all stock in forest tree nurseries should be kept separate by seed sources, and seedlings should be planted in the locality of seed origin or in a similar locality. But in the press of demands for planting stock this is not always possible; seedlings are grown and supplied for planting without regard for seed source; and the planted trees may do poorly even on the most favorable sites. Failure to match planting localities with seed origin localities may account for much of the poor tree growth. Although locality differences in

temperature very likely would be responsible in part, the existence of definite photoperiodic ecotypes associated with latitude has been demonstrated by other researchers, and the poor growth may mean that an unsuitable ecotype was planted.

Some of our preliminary work with Scotch pine supports this theory in part. Seedlings from seed collected at three latitudes were grown under the varying daylengths characteristic of each of these latitudes. As shown in the following tabulation, height growth was greatest in all cases under a variable daylength during the season comparable to that of 50° N. latitude, and the greatest response occurred in the seedlings of the 50-degree source:

Variable light treatment	*Height growth, in cm, by seed source of Latitude—*		
	40°N.	*50°N.*	*60°N.*
Daylength at 40°N.	4.5	4.1	2.6
Daylength at 50°N.	5.2	5.8	5.5
Daylength at 60°N.	3.0	3.9	3.0

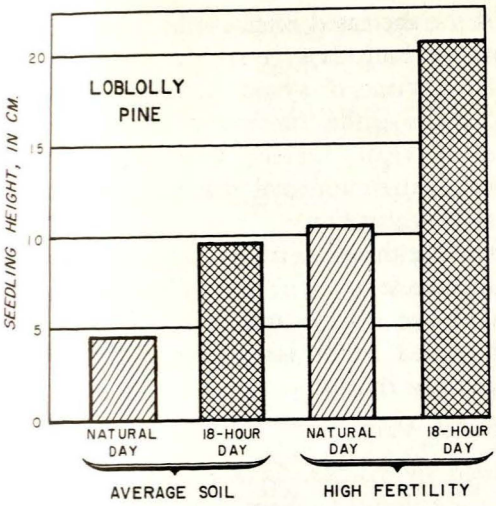
However, that is only part of the story. Temperature, as associated with both altitudinal and latitudinal differences, is also an important influence. Until we fully understand these and other related factors, we cannot use daylength alone to delimit ecotypes.

Length of Day

Quality Control in the Nursery

Production of nursery stock of good quality at a reasonable cost requires a high degree of skill. The forest tree nurseryman must cope with complicated technical problems such as proper fertility levels involving quantity and timing; elimination or control of destructive fungi, insects, and weeds; maintenance of adequate moisture regimes; and provision for seasonal variations in time of sowing of seed, cultivating, and lifting and storage of stock. He must carry out all these operations with sufficient skill to meet quality standards for each species grown.

Planting administrators set up quality standards because some trees or lots of stock do not survive and grow as well as others in the field, even when the seed source is the same. The relationships that experience and research have shown generally to prevail between morphological and, to some degree, physiological characteristics and seedling performance are the basis for the quality standards. The standards specifications usually place primary emphasis on top-root ratios and general size limits, by species. Some of the studies



Height growth of loblolly pine seedlings given four treatment combinations of daylength and nutritional level.

at our Laurel Center showed photoperiodic control potentially to be a very useful tool to the nurseryman in meeting quality standards. For best results, photoperiodic control should, of course, be carefully integrated with nutritional control.

For instance, in one Laurel study, increasing the daylength by two hours for Virginia and loblolly pine seedlings resulted in doubling their height growth over those on natural daylengths. Height growth also was doubled by increasing the nutritional level of the soil. Increasing both the daylength and the nutritional level caused a four-fold increase in height growth.

This example is cited to show that it may well be possible with many species to achieve a predetermined seedling height in a given period of time by controlling daylength and nutrition. Along with height growth, however, one must consider other attributes of the seedlings, such as stem diameters, relative succulence, and root characteristics. These are also influenced by environmental manipulation.

Root length and type were modified by different levels of nutrition of the soil, as would be expected. Increasing the fertility level resulted in greater root length, but no significant increase in mycorrhizae. Varying daylengths did not induce any consistent or significant changes in total root lengths for either Virginia or loblolly pines, except in combination with certain nutritional levels. This suggests that proper combinations of light and nutrition must be determined for every species in order to achieve required quality standards.

Our experiments suggest further that other important results, not now demonstrated completely, may accrue from control of daylength

and nutrition. One example is the increased photosynthetic surface that develops in response to both long days and high nutritional levels. This may lead to greater amounts of stored carbohydrates in the stems and roots at the end of the season. Presence of larger food reserves would increase seedling vigor, thereby increasing their chances to survive under adverse environmental conditions, or to withstand and overcome natural competition.

Another possibility for increasing the efficiency of planting-stock production will be of particular interest to nurserymen. Many species require 2 years or more from seed to reach plantable size. In some species this time may be shortened by at least 1 year through increased growth under photoperiodic control.

Species Vary

Photoperiodic response varied by species. Considerable growth increases were obtained under supplemental light with white oak, sugar maple, paper and yellow birches, black locust, hybrid poplar, and loblolly, Virginia, and pitch pines; moderate responses occurred in red maple, sycamore, and white, jack, and slash pines; a few, such as black cherry, mugho pine, and Norway spruce, failed to respond under the limited treatments used. This does not necessarily mean that the above responses represent inherent species differences —other workers have found that different light conditions affect even some of our nonresponsive species—but it does suggest that further studies are needed.

The lower threshold of photoperiodic response for stem elongation was about 1 foot-candle (ft-c) for red maple, and about 5 ft-c for loblolly and Virginia pines. Intensities above 25 ft-c produced only relatively small additional growth effects under these experimental conditions. The response at relatively low light intensities is encouraging, from the standpoint of future practical use in nurseries, because these intensities will be easier to provide, and costs will probably be less. However, we still need to determine the time during the growing season when length of day can be manipulated most effectively for controlling growth—and do this for each species.

Practical Applications Anticipated

These short briefings on some of the results of our past experimental work with photoperiodism and nutrition—and the hints and implied *ifs* of the ultimate potentials for practical application—show the trends in one small part of our research effort.

We are optimistic that further research both in depth, and in ways of applying knowledge already at hand, will lead ultimately

to production of seedlings of higher quality, to increased efficiency in nursery-stock production, and to greater successes in field planting.

FOREST SITES

Our last full report on site studies was in our 1958 Annual Report. Since that time, the need for being able to classify land for site quality has continued to grow in importance. This is due in part to the intensification of forestry in general, and in part to a better knowledge and appreciation of the utility of a better knowledge of soils and site quality.

One of the first steps in setting up an intensive forest management plan should be to determine the site quality or productivity of the land for the existing species and, if possible, for potentially better species. Site index, when combined with such factors as stocking, age, quality, and economics, can be a powerful tool in forest management.

Since the start of the soils and site work by the Station in 1953, two studies have been completed and the results published: red spruce in Maine and oaks in West Virginia. Additional tests were made recently on the original oak study, and the study was extended to other soils in West Virginia. The first phases of site work on northern hardwoods in Vermont and sweetgum in New Jersey are nearly completed, and plans are being made to extend the work on these species to other areas. In New England a white pine site study involving the cooperation of three universities and the Station is continuing.

Oaks

The original equation developed for estimating site index (base age 50 years) of oaks for the mountain and plateau area of northeastern West Virginia and the mountain area of northwestern Maryland was based on four factors: aspect, percent slope of the land, position on slope, and total soil depth. The soils included all of the well-drained, medium-textured, upland soils derived from sandstone and shale except the Ashby soils. The equation had a correlation coefficient of 0.87, significant at the 1-percent level. In field-testing the equation has given results that conformed well to tree data.

This old site data was recently strengthened by the addition of some new plots, and a re-analysis showed that a good estimating equation could be developed from the first three factors alone, omitting soil depth data. The correlation coefficient for the new equation is 0.86 and is significant at the 1-percent level. This is gratifying since

soil depth is the most costly and difficult to measure of the four variables.

Field work has been completed on an oak site study on the Belmont series, which are derived from limestone. The data, taken from the same area where the earlier study was made, has not been thoroughly analyzed yet, but preliminary analysis indicates a significant difference between site index on the limestone soils and site index on sandstone and shale soils with similar topographic and depth characteristics. In general, site index on the limestone soils appears to be higher; better quantitative definition of the relationship will come from more complete analysis.

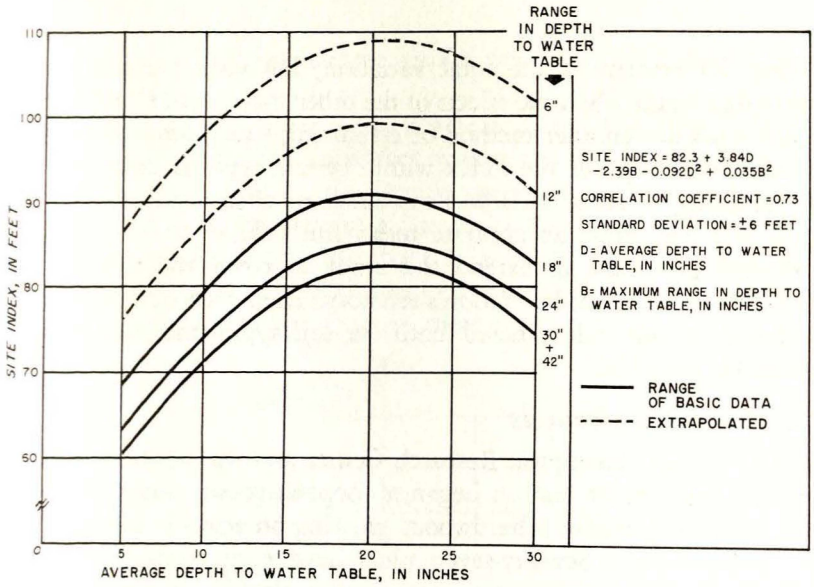
Field work is now nearing completion on another oak site study in the ridge and valley area of West Virginia and Maryland east of the Alleghenys. While soils are similar to those of the original study area, annual rainfall averages 15 to 20 inches less. It is anticipated that this lesser amount of precipitation will be reflected in lower site indexes.

Sweetgum

Field work on the New Jersey sweetgum study began in the fall of 1959. This was a cooperative effort by the New Jersey Department of Conservation, the Soil Conservation Service, and the Station. New Jersey CFM foresters located usable sweetgum stands; personnel of the Soil Conservation Service collected soils data; and the Station's New Lisbon Research Center obtained data on tree heights and ages and made the analyses.

The 61 areas studied were distributed throughout the hardwood region of the New Jersey coastal plain. These areas are all nearly flat with slopes of less than 1 percent, the soils are poorly or very poorly drained, and the stands of sweetgum are even-aged and of old-field origin.

Site index (base age 50 years) was correlated with groundwater characteristics, soil characteristics, and soil type. Highest site-index values were correlated with an average depth of 20 inches to water table and with the least fluctuation in water-table position. These conditions prevailed especially in recent alluvial deposits where water-table levels are controlled by adjacent streams. The lowest site-index values were correlated with very high or very low water tables, and with fluctuations of 2 feet or more. Fluctuations in depth to free water greater than 2 feet have little effect on site index, and in these areas of maximum fluctuation other soil properties assume greater importance.



Site index for sweetgum as it was correlated to fluctuations in depth to the water table during the growing season and to average depth to the water table.

For soils other than recent alluvial deposits, site index varied with texture and thickness of the B_2 horizon, and with the difference in texture between the A and B_2 horizons. The equation relating these variables to site index is:

$$\text{Site index} = 26.4 + 0.49X_1 + 1.49X_2 - 0.015X_3 + 0.78X_4 - 0.023X_5 + 1.38X_6 - 0.049X_7$$

where:

X_1 = percent clay of the B_2 horizon,
X_2 = percent fine sand of the B_2 horizon,
$X_3 = (X_2)^2$,
X_4 = difference between percent silt plus clay in the B_2 horizon and percent silt plus clay in the A horizon,
$X_5 = (X_4)^2$,
X_6 = positive difference between 12 inches and the thickness of the B_2 horizon, in inches,
$X_7 = (X_6)^2$.

The multiple correlation coefficient for this equation is 0.817, and the standard error of estimate is ± 5.7 feet. Of the four independent variables, clay and fine sand were the most important, together re-

moving 50 percent of the total variation; but each variable was highly significant when the effects of the other three were eliminated.

Soil types are another method of estimating sweetgum site index, although the range in site index within certain types is large. Also, our sampling of some soils was too small to adequately assess the range and determine an accurate mean site index.

Present plans are to extend this study to cover the remaining range of sweetgum in the Station's territory. Then even more reliable estimates of site index, based both on soil types and regression, should be possible.

Northern Hardwoods

In 1957 our Burlington Research Center and the Vermont Agricultural Experiment Station began a cooperative site study dealing with even-aged northern hardwoods growing on acid till soils in the Green Mountains. Seventy-seven plots have been established, and analysis of the data now in progress has already produced some results of interest.

Site-index curves for use in this study were prepared from stem analyses of sample trees. A base age of 75 years was used for these curves instead of the conventional base age of 50. The greater base age coincides better with the sustained height-growth habits of the northern hardwood species.

An early analysis of the site data suggested that appreciable distortions sometimes are introduced into site curves as a result of a relationship between site quality and stand age. The older stands tend to occur on the poorer sites, since stands on the better sites reach merchantability at younger ages. A procedure was developed for correcting such distortions, before the final site curves were completed.

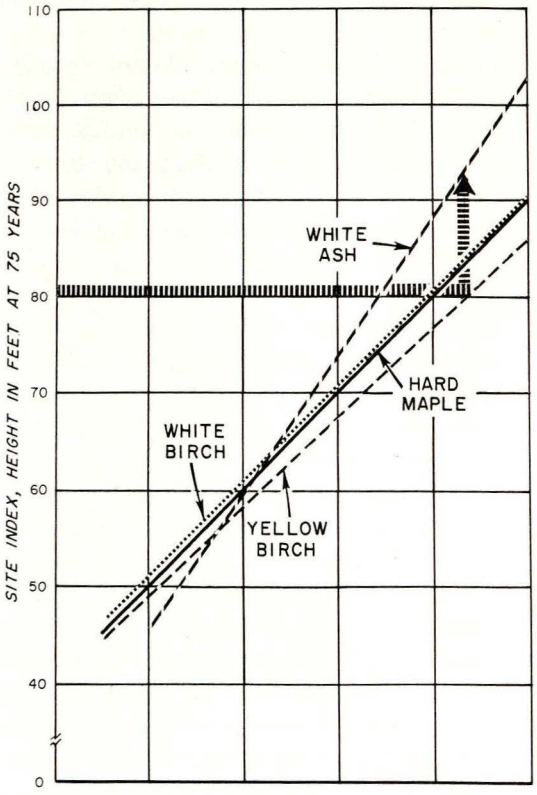
Analysis of factors of the soil and topography in relation to site index is still in progress; preliminary indications are that soil-drainage classes and topographic position may be the important factors that are related to site index.

In addition to the main objective of relating site quality to soil and topographic factors, a byproduct of the study has been the correlation of the site indices of the four northern hardwood species where they were found growing together on the same land.

High correlations appear to exist between measured site indices of the different species, where they occur on the same land areas. From these comparisons it is clear that white ash is considerably more sensitive to differences in site quality than are the associated species. These relationships can be used to estimate the site index of

any one or all of the other three species when the site index of one species is known.

Both volume and quality of northern hardwood stands differ widely with site. Average cubic-foot volumes of fully stocked stands at a breast height age of 75 years range from about 1,900 cubic feet per acre in stands having a site index for sugar maple of 50 feet (base age 75 years); to about 5,100 cubic feet per acre for stands of site index 90. And there are corresponding differences in average tree size and quality on these sites.



Comparison of measured site indices for four northern hardwood species on acid till soils in the Green Mountains of Vermont. When the site index of any one species is known, the site indices of the others can be estimated. For example, to estimate the site index of white ash corresponding to site 80 for yellow birch, read right from 80 to the yellow birch curve, then read up to the white ash curve. In this case it is 93.

White Pine

A white pine soils, site, and growth study was begun 2 years ago as a cooperative effort of the Universities of Maine, New Hampshire, and Massachusetts and the Northeastern Station. Most of the plots have been established, and initial stand and tree measurements have been taken. The second phase of sampling soils and topography on

these plots is now under way, and the third phase of the study is to remeasure the stands and trees on the plots after 2 or more years of growth. Then the possible relationship of this periodic growth to soils, topography, and other environmental factors is to be investigated.

OTHER RESULTS

Natural Regeneration

Natural regeneration—how to obtain it and how to control it—is a major concern to most forest managers, and a crucial phase in most management programs. All of the Station's research centers are devoting some attention to it.

At our Elkins Center, 10-year reproduction surveys after cuttings of different kinds and intensities on the Fernow Experimental Forest have shown that almost any kind of cutting in saw-timber stands of that area will result in abundant reproduction of tree species. Light selection cutting favors reproduction of tolerant species, particularly sugar maple; heavier cutting enables more intolerant reproduction to become established, but also results in more sprout growth. Sprouts may make up 35 percent or more of the new stands after commercial clear cuttings. Species composition of reproduction is influenced also by site quality. Yellow-poplar, for instance, comes in abundantly after heavy cutting on the best sites but rarely on fair or poor sites; oaks are affected conversely, coming in most abundantly on the poorer sites.

Research on paper birch regeneration is under way at both our Bangor and Laconia Centers. In a study at Bangor (briefly noted in our 1959 report), a paper birch stand was clearcut in 1958, and the natural regeneration is being compared on four seedbed conditions: after winter logging, after summer logging, disking after winter logging, and burning after winter logging. Seedfall of paper birch from residual seed trees on the study area was estimated from trap records to be 1.3 million seeds per acre in 1958, 0.8 million in 1959, and 16.8 million in 1960. Estimated viability of the three crops was 13, 24, and 77 percent, respectively.

At the end of the third season, paper birch comprised 48 to 87 percent of all stems on the treated areas. Disked areas had both the highest percentage and the largest number of paper birch seedlings —121,000 per acre. Numbers ranged from 14,000 to 23,000 seedlings per acre on the other seedbeds. Dominant or free-to-grow seedlings averaged 0.9 to 1.2 feet tall, but about two-thirds of the paper birch seedlings were less than 6 inches in height.

The Laconia study also involves comparisons of different seedbed conditions ranging from mineral soil to undisturbed litter and humus. First-year results (reported in 1959) showed germination and survival to be far higher on mineral soil than on other seedbeds, but growth was almost twice as much on humus as on the others. Since 1959, attention has been directed mainly to study of the environmental factors. Soil moisture and soil temperature appear to be the limiting factors in germination and survival. Mineral soil seedbeds and shady locations provide the moisture and moderate temperatures that are most favorable. On the other hand, light and nutrients are the more important determinants of height growth. Once established, seedlings grew best in full sunlight and on organic seedbeds, which provided substantially more nutrients than mineral soil.

A new study is now being started at Laconia for more intensive study of the basic factors of light and moisture in relation to establishment and growth of birch seedlings.

Natural regeneration of white ash also is under study at the Laconia Center. The Laconia study involved three seedbed treatments under three overstory densities; ash seed was sown artificially on the plots. Many seeds did not germinate until the second year, and a few laid over until the third year. Overstory density had little effect upon initial germination and survival. Best combined catch of seedlings for the first and second years after sowing was on seedbeds that were scarified after sowing, thereby covering most of the seed. When seed was sown after seedbed scarification, or with no seedbed treatment, only about one-fourth as many seedlings became established as where scarification followed the sowing.

Planting

Planting tests with paper birch were begun in 1958 and 1959 in old fields by the Bangor Center in cooperation with the Maine Hardwood Association. Variables included site preparation, fertilizer treatments, mulching, and animal repellents. Survival and growth have been best in plantings on the slice of a double furrow and poorest in sod; scalps and furrow bottoms rank in between. The fertilizer and mulch treatments gave inconclusive results.

Animal damage, particularly mouse damage, has been more or less severe in all plantations; the repellents used have not been very effective against deer, rabbits, or mice. Tests of poison baits now are being tried for mouse control in cooperation with the U. S. Fish and Wildlife Service. Although survivals around 70 percent have been obtained in the furrow-slice plantings, growth has been rather poor: some trees die back each season and make no net height growth;

An unthinned 44-year-old mixed plantation in Potter County, Pennsylvania. Left to right are rows of white pine, European larch (dead trees on ground), red pine, and Norway spruce. Suppression of the larch and spruce has had an effect similar to that of row thinning.

26-year-old Japanese larch on a strip-mine bank in Jefferson County, Pennsylvania. This stand is growing at a rate of 100+ cubic feet per acre per year, and contains trees more than 10 inches d.b.h. and 68 feet high.

those that have increased in height have averaged only 5 to 9 inches per year. In view of the animal depredations and the very mediocre growth, these old-field plantings do not offer very glowing prospects as a means for establishing paper birch stands.

About 40 plantations in western Pennsylvania that now are 35 or more years old have been re-examined for volume growth and species performance on various sites. Volume data have not yet been analyzed, but from the general observations, red pine, Japanese larch, and European larch can be named as among the best species. Two larch plantations had made mean annual height growths of 1.7 and 1.8 feet. Few of the plantations had ever been thinned. In some row-by-row species mixtures, suppression of one or more species has resulted in rather effective natural thinning.

Surveys of 7-year and older plantations on graded strip-mine banks in Pennsylvania's bituminous region, conducted in 1960 by our Kingston unit, showed that Scotch pine, Japanese larch, and black locust generally grew best on these sites. Banks, pitch, red, white, and Austrian pines also grew well in most areas. However, red pine

often was severely damaged by the European pine shoot moth, and black locust by the locust borer.

Plantations more than 20 years old were examined with particular reference to the potential of different species to produce merchantable stands. Both Japanese larch and Scotch pine stands on the better bank sites were growing more than 100 cubic feet per acre per year. White pine, although a slow starter, maintains a rapid rate of growth after the first 10 years, and ranks high as a potential timber producer. Growth rates of pitch pine and Banks pine tend to slow down after 15 years; these species averaged only slightly more than 50 cubic feet per acre per year over a 25-year period. The data on these older plantations definitely indicated that properly planted strip-mine banks can produce commercial timber stands.

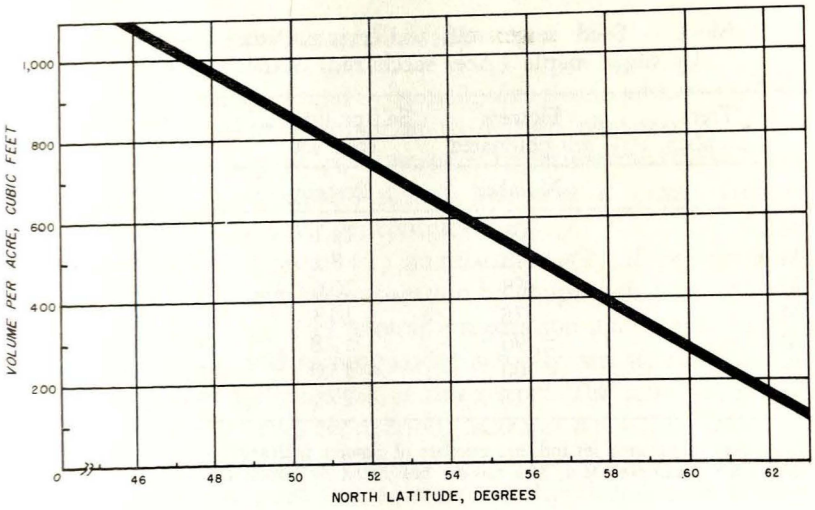
IUFRO Scotch Pine Provenance Tests

In 1938 the International Union of Forest Research Organizations (IUFRO), through its Subcommittee for Forest Seed and Forest Tree Races, supplied Scotch pine seed of various provenances for test plantings in the United States. Plantations from this seed were established in New Hampshire and New York during the period 1940-42. One of these plantations, established by the New York Conservation Department in 1940 near Hinckley, N. Y., contains 30 provenances representing origins from 46° 40′ to 61° 44′ north latitude. The plantation site in New York is at 43° 42′ north. This plantation was re-measured in 1957, when the trees were 19 years old from seed. The data have recently been analyzed and a report soon is to be published.

Average heights of the different provenances varied from 17.5 to 27.3 feet. Average provenance heights were negatively correlated with latitude north, and positively correlated with length of growing season of the locality of seed origin; statistically these correlations were significant at the 1-percent level. Both correlations express the same basic trend: that the farther north the seed originated, the less the height growth in the New York plantation.

Cubic-foot volumes per acre of the various provenances, like their heights, were negatively correlated with the latitude of origin (statistically highly significant). However, when the provenances were classified by tree form, the numbers of straight-stemmed trees per acre were found to be the highest in the more northern progenies; that is, the higher volume production of the more southern provenances was associated with poor stem form.

Of interest to Christmas tree growers was the better winter color



Effect of provenance. Volume production of 19-year-old Scotch pine in New York decreases rapidly with increasing latitude of seed source.

of trees of southern origin. Color ratings were made in the early 1940's on seedlings in the nursery at Saratoga, N. Y. For environments similar to that of the Saratoga area, Scotch pine from origins south of 53°N. latitude and below 500 meters elevation seem to offer the best assurance of holding color acceptable for Christmas trees.

Studies of Maple Flowering

Detailed studies of the flowering and fruiting behavior of sugar maple at our Burlington Center have revealed that the pollen sacs in hermaphroditic flowers ordinarily do not burst under natural conditions. Consequently, such flowers can be control-pollinated without going through the tedious job of emasculation.

Sugar maple is dichogamous; that is, in the flowers of any one tree, stamens and pistils tend to mature at different times, thus precluding or reducing self-fertilization. Temperature probably determines whether dichogamy within a tree is complete or partial. In 1958, when temperatures during the week after bud burst averaged 11°F. below normal, dichogamy within trees was complete; in 1960, when temperatures during the comparable period averaged 12° above normal, dichogamy was incomplete.

Table 1. — Seed set to self- and cross-pollinations in 1960 by sugar maple (Acer saccharum Marsh.) trees

Trees number	Flowers self-pollinated	Self-pollinated seed set	Cross-pollinated seed set
	Number	Percent	Percent
M-1	108	11.1	—
M-4	148	8.1	27.5 (364-5)[1]
M-6	68	20.6	43.3 (402-5)
M-7	78	10.3	23.2 (82-2)
M-13	96	19.8	40.5 (496-5)
H-509	100	13.0	23.8 (286-3)
H-573	118	27.1	36.4 (350-4)

[1]Numbers in parentheses indicate number of flowers pollinated and number of male parents used. Example: M-4, 364 flowers pollinated by pollen from 5 different trees.

Individual trees were found to be self-fertile in varying degrees (table 1). Results from a series of reciprocal crosses indicate that most trees are compatible with each other.

All such information on its flowering and fruiting habits will enable us to move into breeding research with sugar maple with greater confidence and efficiency than would otherwise have been possible.

Viable Seed from Premature Collections

Virginia pine seed collected as much as 11 weeks before natural seedfall will become viable if properly handled, according to a 1960 study at our Laurel Research Center. In an earlier study (reported in our Forest Research Note 102), seed collected up to 8 weeks before natural seedfall exhibited fair to good viability without any special treatment.

Seed collected prematurely by 11 weeks in the 1960 study would not germinate even after 14 days' storage on moist peat at 5 °C. But after a period of sealed cold storage, followed by 2 days on moist peat at 5 °C., more than 70 percent of the seed germinated. Minimum specifications have not been determined, but both of the following regimes were effective: (1) cones stored 3 to 14 weeks at room temperature; extracted seed then stored 8 weeks in sealed containers at 5 °C; then 2 days on moist peat at 5 °C. (2) seed extracted soon after collection and stored 12 to 29 weeks in sealed containers at 5 °C., then 2 days on moist peat at the same temperature.

Environment and Direct Seeding

White pine seed was found to be more sensitive to adverse environmental factors during germination than pitch pine seed in a plot study of direct seeding on the Massabesic Experimental Forest. These observations on germination represent one facet of a more comprehensive study, which is not yet completed.

The plot treatments were: (1) no treatment, (2) 50-percent shade (under cloth), (3) ground preparation by scalping or turning under the blueberry sod, and (4) ground preparation and shade. In (3) and (4), scalping and turning-under actually are separate ground treatments pooled for purposes of this report. The same treatments were applied on two sites representing two soil types. The following tabulation of germination percentages shows the consistently stronger germination of pitch pine, and the response of both species to reduced competition and amelioration of microclimate:

	Excessively drained loamy sand		*Well drained stony sandy loam*	
Treatment	*White pine*	*Pitch pine*	*White pine*	*Pitch pine*
None	2.5	27.0	30.0	37.0
50 percent shade	21.0	40.0	41.0	49.0
Ground preparation	17.0	39.0	—	—
Ground preparation + shade	42.0	67.0	53.0	66.0

White pine also was more sensitive to adverse factors in terms of seedling survival than pitch pine. For instance, with ground preparation but without shade on the excessively drained soil, 69 percent of the white pine germinates died in two years, as compared to 27 percent of the pitch pine.

Prolong Dormancy of Nursery Seedlings

If dormancy could be prolonged in nursery stock during the lifting and planting period, the season for these operations could be extended and the plants would reach the planting site in better condition. The larches, in particular, are subject to injury because their buds commonly start growth in the spring before they can be planted—sometimes even before they can be lifted. Maleic hydrazide (MH), which in the past has been used mainly as a growth retardant on grass, was tested on coniferous seedlings as a possible means of prolonging their dormancy. These tests were part of a more comprehen-

sive study of chemical treatments for controlling seedling growth that the Kingston Unit is conducting in cooperation with the Pennsylvania Department of Forests and Waters at two state nurseries.

Late in the 1960 growing season, sprays of MH ranging from 0.025 percent to 0.5 percent were applied to seedlings of Japanese larch, white pine, and Norway spruce. Japanese larch was treated just before and during bud-setting, and also after the seedlings were dormant. Only dormant sprays were applied to white pine and Norway spruce. Both of the latter species were slightly damaged by MH as applied in these tests.

The most promising treatment was a 0.1-percent dormant spray on Japanese larch. At the time of out-planting in early April, 60 percent of the treated trees still were dormant, as compared to 5 percent of the controls. Four weeks later, 86 percent of the treated trees had burst most of their buds, as compared to 98 percent of the controls. Growth of these trees will be followed in plantations to determine whether the treatment caused any lasting detrimental effects.

Small Woodlot Management

Stands of maple, beech, and black cherry can be improved in both volume and quality of growing stock while making frequent light cuts to effect improvement and provide an income. This was accomplished on two stands on the Pocono Experimental Forest despite two major windstorms during the 9-year period of record and rather low stocking in parts of the stands.

Both stands were improved in quality, as shown by the increased volume in sawlog-grade material (table 2). This resulted from both

Table 2. — Inventory and production[1] record for combined woodlots
(Cubic feet per acre)

Item	Product classes		
	Sawlog-grade material[2]	Other material	Total
1949 Inventory	525	1,223	1,746
Volume removed	133	255	388
1958 Inventory	644	1,137	1,781
Production	254	169	423

[1]Inventory change plus volume removed.
[2]Sawlog-grade material qualifies for Forest Products Laboratory hardwood log grades 1 through 4; other material includes local-use logs, pulpwood, and cull.

A year's growth on a shortleaf pine. The upper two internodes are summer shoots, and the branch whorls at their bases are similar to those at the base of the spring shoots. At the top of the leader is a newly elongating summer shoot of the current year.

ingrowth and deliberate selection of low-quality trees for removal. Board-foot volume production in one stand was 250 board-feet per acre per year on a growing stock of 4,900 board-feet per acre. The other stand produced 150 board-feet per acre per year on growing stock of 2,900 board-feet per acre. These increases were at a rate of approximately 5 percent in each stand.

Multinodal Leader Growth in Pines

In a detailed study of leader development in young pitch and shortleaf pines at our New Lisbon Center, the highly synchronized sequence of growth processes was followed through one growing season. The winter buds of both species are multinodal, and may produce two or more whorls of branches. Spring growth begins in the basal internode, progressing in sequence through the succeeding internodes; the growth curve of each internode is sigmoid and each achieves its peak rate after that of the internode below it. In vigorous young trees, as growth of the winter bud nears completion, the shoot apex may form a new bud that promptly elongates to form a summer shoot. Summer shoots are produced much more commonly by shortleaf pines than by pitch pine; in fact, shortleaf often produces two or more such shoots in succession.

These growth characteristics, marked by development of several whorls of branches each year, are important in attempts to estimate tree age from branch whorls. In pitch pine, age can be read with a fair degree of assurance because: (1) lateral buds located directly below the winter bud produce the largest branches; (2) if the

winter bud had been multinodal, only whorls of small rudimentary branches or buds would usually be found between the principal whorls; and (3) often no summer shoots develop, and if they do, the resulting stem section is relatively short, and branches at the base of this shoot usually are smaller than those in the next higher whorl.

In shortleaf pine, estimating age is more difficult because more of the nodes are derived from summer buds, and the branches at the base of each summer shoot often are almost as large as those at the base of the spring shoot. Furthermore, the spring-shoot and summer-shoot internodes may not differ conspicuously in length.

Watershed Management

WHAT happens to streamflow from a small forested watershed if all the trees are cut down? If half of them are cut? Or if only few are taken? What are the effects on water yield? On water quality? On peak flow? On low flow?

To meet questions like these, we in the Northeast were forced to go outside our region for answers, looking to research results from other experiment stations.

No longer is this so necessary. This year, from watershed studies at our Fernow Experimental Forest in West Virginia, we prepared two reports describing the effects of various degrees of forest cutting on streamflow. And, continuing our search for similar information for areas to the north, we added to our network five experimental watersheds (three at State College in Pennsylvania, and two at the Hubbard Brook Experimental Forest in New Hampshire). Seeking answers as to why and how the forest cover influences streamflow, we devoted continued effort to collecting climatic and soil data. And our search for a means of making our watershed research results more useful moved us to develop a regional program of some unity and direction.

The Fernow Results

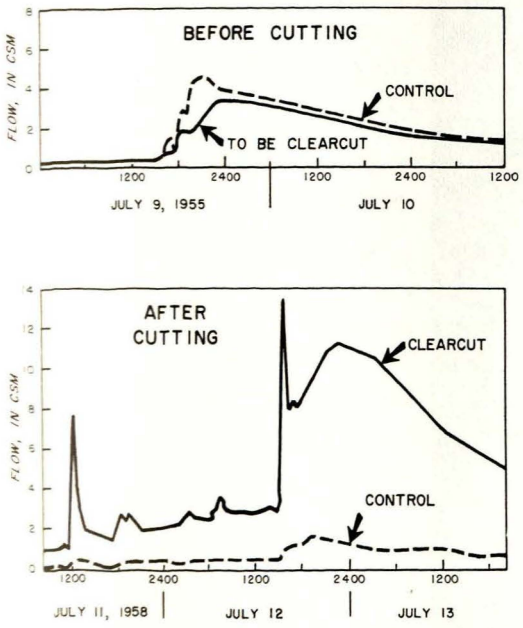
The first 3 years of streamflow records, begun after four of the experimental watersheds on our Fernow Experimental Forest were cut over, revealed the following:

- Annual flows increased—as much as 5 inches on the clearcut watershed the year after treatment—and the increases were in relation to the amount of material cut.
- Most of the increase came in the growing season. For instance, from May to October 1959, increases were as follows:

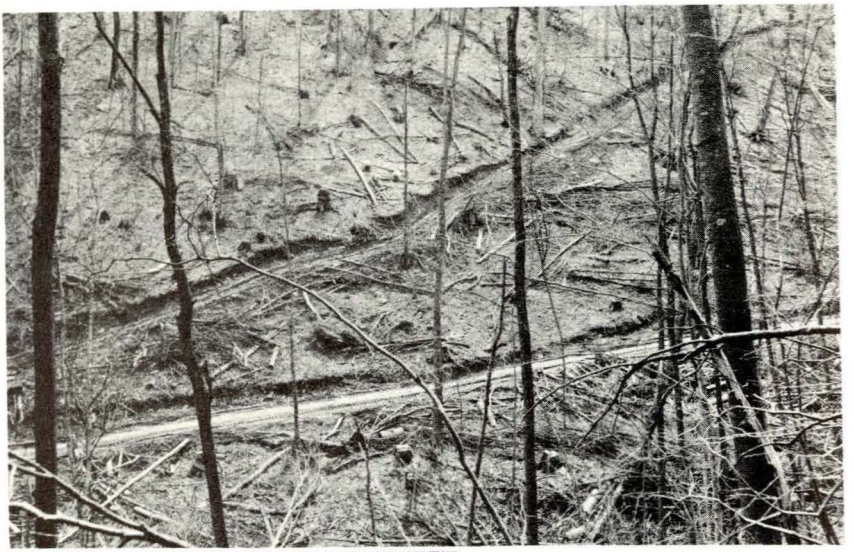
Type of cutting	*Material removed M bd.-ft. per acre*	*Increase in flow (inches)*	*(percentage)*
Commercial clearcut	8.5	3.0	111
Diameter limit	4.2	1.8	53
Extensive selection	3.7	1.4	33
Intensive selection	1.7	.3	9

What does this mean in terms of drinking water? One insight: on a 50-acre watershed basis, the above four increases in flow are equivalent, in descending order, to roughly 4 million, 2.5 million, 2 million, and 1/2 million gallons of water.

- Peak flow changes were small except on the clearcut watershed where, on the average, instantaneous peaks during the growing season were increased by 21 percent. The average dormant-season peak flow was not affected.



Sample hydrographs of the clearcut and control Fernow watersheds before and after clearcutting.



After this watershed was clearcut (above), water yield increased 111 percent during the first growing season. But regrowth (below) the next year was a major factor in reducing this increase in water yield to 35 percent.

- Increases in low flow were striking. These too were related to the amount of timber cut. In 1959, for instance, 99 days of low flow (flow less than 50 gallons per acre per day) would have been expected from the clearcut watershed, based on pre-treatment flow—but only 36 days actually occurred. On the diameter-limit cutting, expected and actual days were 74 and 27; on the extensive selection cutting, 58 and 37; and on the intensive selection cutting—the least affected—65 and 60. In each case there were fewer low-flow days than would have been expected on the watersheds before treatment
- Care in the logging operation was clearly reflected in water quality: maximum turbidities ranged from 56,000 ppm on the clearcut watershed, with unplanned skidroads and without provisions for drainage, to 25 ppm on the intensive selection watershed with carefully planned skidroads.

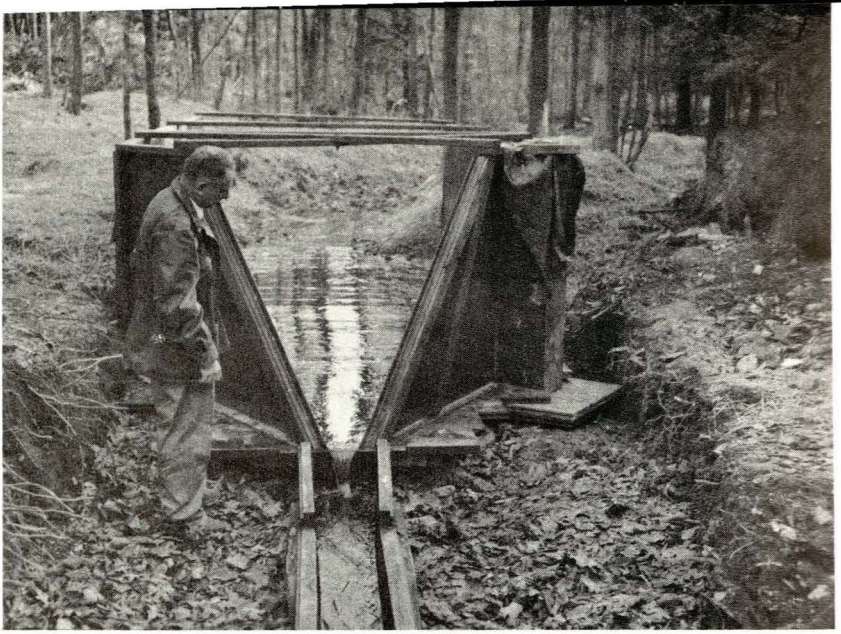
These effects are rapidly fading. For example, turbidity during the logging operation averaged 490 ppm; the first year after logging it dropped to 38 ppm, and the second year to 1 ppm. Water-yield increases likewise decreased: growing-season increases in 1960 for the four logged watersheds were only 44 percent of those in 1959. To record the diminishing response of the watersheds to cutting, streamgaging is continuing and records and analyses are being kept up to date.

Watershed Calibration

While the Fernow results were being analyzed and reported, water-level recorders and climatic instruments traced on charts another year of calibration record at the four Hubbard Brook experimental watersheds in New Hampshire, the three Newark, N. J., watersheds, three at Baltimore, Md., and three at State College, Pa. Another year of record was also obtained on the nine watersheds on the Fernow Forest in West Virginia. To this network were added three watersheds at State College, Pa., bringing the total for this cooperative project to six; and two were added to the Hubbard Brook network, also for a total of six.

An account of our weir-building experiences at these places has been prepared for publication. It offers how-to-do-it instructions in detail, from locating the weir site to winterizing the installation. One interesting development is the successful use of vinyl plastic as a water-tight lining for one of our weir ponds during the past 2 years. A lining of butyl rubber is being tried in one of our new weirs.

A major job completed was the calibration of the Dilldown watershed in the Pocono Region of Pennsylvania. As this was a



Watershed installations have provided considerable experience in weir building. Above, a 4.5-foot H-flume built of redwood and Douglas-fir at State College, Pa.

Below, left, the San dimas flume and 90° V-notch weir at Hubbard Brook in New Hampshire; storm flow is measured by the flume, and low flows by the V-notch weir. Right, close-up of the flume. Storm flow jumps across the concrete trough, thus bypassing the V-notch weir.

single watershed (without a control), the calibration required us to develop means of predicting seasonal and annual water yield from climatic variables that would not be affected by watershed treatment. This was done on the basis of a 6-year daily record of streamflow, precipitation, and air temperatures; and the resultant regressions were tested, with some success, on the subsequent 4-year record. Results were published by the Pennsylvania Department of Forest and Waters in a fourth report on this cooperative project.

Rain, Snow, and Sun

Two reports on rainfall interception at Hubbard Brook described the amount of rainfall caught by the canopy during the leaf season (0.13 inch for a 1-inch storm), during the dormant season (0.09 inch for a 1-inch storm), and the extraordinary variation from spot to spot in the amount of rainfall that reaches the forest floor (ranging from 0.52 to 1.14 for a 1.02-inch storm).

Two other papers dealt with snow accumulation and melt in the Adirondacks under hardwoods and conifers, the development of a simple method for predicting maximum snow-water content, and comparative accumulation of snow on the branches of different conifer species. Results from a snow study in New Hampshire were tied to the Adirondack results and a new correlation study was started just south of Syracuse, N. Y., in the Allegheny Plateau. From these we expect to obtain a good picture of forest-snow relationships in the snowpack zone of the Northeast.

Emphasis on rain and snow was balanced by a cooperative effort to review the literature on solar radiation as it pertains to forestry, with Dr. William E. Reifsnyder (associate professor of forest meteorology at Yale University School of Forestry) leading the way.

Cooperative Research

Our research program was strengthened by initiation of a cooperative research project with the State University of New York College of Forestry at Syracuse. Work is under way on a problem analysis and research program; a snow study will be made this winter; and a program conference is scheduled for early 1962. Programs are people: In this case Arthur Eschner is our on-the-spot watershed researcher, and he is working closely with the College's Prof. Donald Satterlund, who is in charge of watershed instruction and research. This project will help to fill the big gap between our cooperative studies in Pennsylvania and the Hubbard Brook program in New Hampshire.

A quite different study was started in cooperation with Paul Felton, executive director of the Wisconsin Valley Watershed Association. The watershed, which lies just north of Philadelphia, is partly urban, partly expanding suburbs, and rural to a continually

Looking straight up at the tree canopy above a throughfall gage used in the interception study at Hubbard Brook. Above: the multi-layered canopy in leaf. Below: the same view in the leafless period.

lessening degree. Small studies of the influences of suburbanization on watershed hydrology are planned.

Our cooperative research program with the Bureau of Water Supply, Baltimore, Md., the City of Newark, N. J., and the School of Forestry of The Pennsylvania State University continued with cooperators taking records and maintaining installations. Their continuing interest and efforts are gratifying.

The Regional Program

The regional research program, mentioned at the beginning of this report, calls for several different approaches: One is to continue present watershed investigations. Another is to intensify on these watersheds studies of the hydrologic processes so as to better understand their integral streamflow. A third is to survey all experimental watersheds in respect to soils, vegetation, topography, geology, drainage net, and climate as a basis for understanding their differences in streamflow and also to describe better the areas from which our research results stem. A fourth is to classify northeastern streamflow, if possible, by subregional zones of similar parent materials or topography and to relate our experimental watersheds to these zones. A fifth is to assemble and keep current information on the hydrology of the Northeast—snow accumulation and melt, soil-moisture drying rates, interception studies, and the like.

These approaches offer a coordinated means of extending research results to areas of application. Or so we think.

Forest Insects

BECAUSE the forest represents a long-term crop and the values engendered by it other than timber are not readily assessed in terms of dollars and cents, the emergency-action approach to forest insect control is viewed with caution by most forest managers. A proven means of suppressing a damaging infestation of a particular pest may be at hand, but its feasibility or worth may be uncertain. Will the control effort have any lasting effect? Will the cost of con-

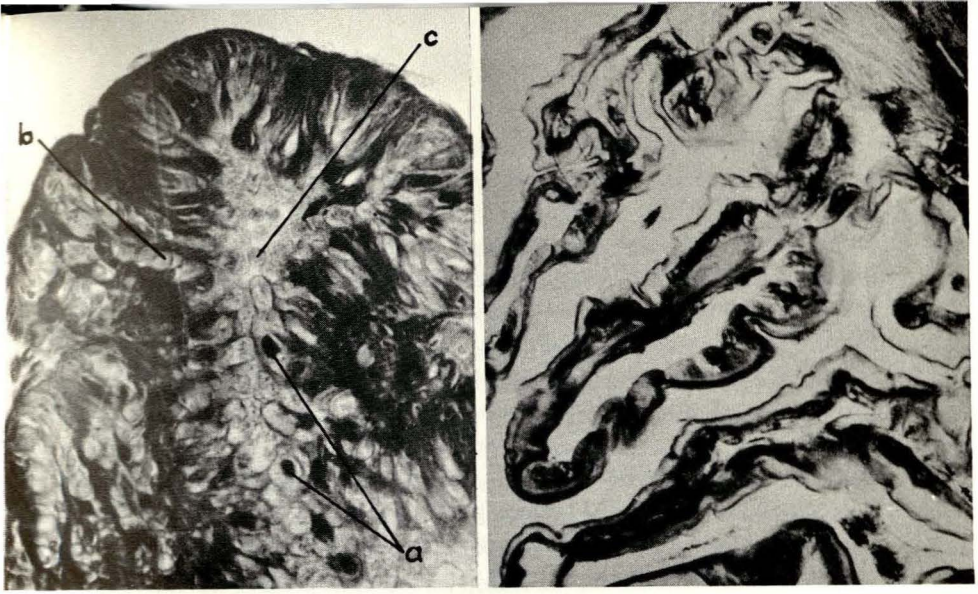
trol really pay off in value gained? Is a pattern of high-cost protection being started here? And, equally pertinent perhaps: Is it a sound idea to let an infestation develop to the point where quick emergency action is needed—in the hope that natural control factors will intercede?

Spectacular suppressive effects by potent insecticides and other means dispel such doubts, generally; but there remains the intuitive feeling that true protection against destructive insects should be a long-term process geared to the time span of the forest crop. Resort to the large control operation with chemical insecticides, justified on the basis of emergency action, should not be necessary.

What alternatives are there? In many cases at present, none. The trees must be saved, raw wood must be kept in supply for local industry, and other forest values must be preserved—and DDT or one of its cohorts provides the only practical answer. However, new research findings and recent developments in the production and use of microbial agents, chemosterilants, and antimetabolites give us a new arsenal of defense. Genetic manipulation by means of gamma radiation, interracial crosses, and other means gives promise of yet another weapon—insidious and far-reaching—against the insect enemy. All of these should be integrated effectively to prevent the buildup of insect populations as well as to suppress the insect under epizootic conditions.

Treatment of the forest stand or plantation to reduce the chances of insect attack and keep the individual tree vigorous and resistant to injury ("silvicultural control") has the greatest appeal to the forester. And rightly so, because if effective it is most easily incorporated into a management plan. Unfortunately, we do not yet know enough about the interrelations of most of our major pests and their hosts to make definite recommendations. The trial-and-error approach used thus far has provided little real information and erratic success at best.

The Division of Forest Insect Research has realigned its program (1) to give more emphasis to the development of new methods of direct control, utilizing both biotic and chemical agents; and (2) to obtain more fundamental ecological information for a deeper insight into the true impact of destructive insects on the forest and the development of indirect means of control by manipulation of the forest environment. The research effort is now concentrated at our New Haven Laboratory, and further stimulus has been provided by the shift of survey and pest control responsibilities to the Regional Office (R-7). Following are some highlights of our current research and a brief resumé of the whole program.



Normal condition of gypsy moth midgut. Note healthy turgor of cells and clearly defined nuclei and cytoplasm (a). The tissues are compact; secretory cells (b) and mesenchymal cells (c) are present. Much enlarged.

Diseased condition of gypsy moth midgut due to bacterial infection. Note collapsed appearance of tissues and absence of well-defined nuclei. The secretory and mesenchymal cells are missing entirely. Much enlarged.

Detailed laboratory and field tests of the bacterial pathogen, *Bacillus thuringiensis,* were conducted against the gypsy moth. As information on the gut pH of a specific insect in its successive stages (particularly the active feeding stage) and in different conditions is needed to fully evaluate the action of *B. thuringiensis,* determinations were made of the pH of the several sections of the alimentary tract and blood of instar IV, V, and VI (female) gypsy moth larvae. The measurements ranged from an average of 6.3 in the blood to 8.3 in the mid-gut, with no significant difference between instars or resting versus feeding (on red oak foliage).

This microbial insecticide is reported most virulent when ingested by insects with a gut pH of 9.5 or higher, but pathogenicity tests in the laboratory showed it to be virulent against young gypsy moth larvae. In these tests, various combinations of the bacterium in water and adjuvants were tried at three dosage levels similar to those chosen for field testing. A tung-oil sticker adversely affected the immediate killing action, and a 4-day weathering of treated foliage reduced the effectiveness of all formulations.

Additional information was needed on the germinability of spore preparations of *B. thuringiensis.* The spores will germinate quickly when placed in tap water, and the effectiveness of the material is much reduced if spore germination occurs prior to ingestion by the insect. Using two buffering systems and a special feeding technique, it was found that spore germination could be retarded by buffering the preparations at pH 3 to 4 and that a water suspension could be stored safely for 2 days if treated in this way. Nonbuffered tap water suspensions of spores germinated completely in less than a day.

The effect of *B. thuringiensis* on feeding behavior of young larvae was also investigated in the laboratory. Direct observations over an 8-day period showed that ingestion of the material strongly inhibited subsequent feeding activity. No repellent effect was noted.

The cadavers of the larvae killed in the laboratory were examined for spores and parasporal bodies (the crystalline toxin) produced by the bacterium. Sporulation began between the second and third day after death, and all cells completed sporulation by the sixth day. Crystal formation was not inhibited in any way. This was a very important finding, because production of new spores and the toxic crystal in treated gypsy moths presents a possibility of the disease organism being carried over into subsequent generations. This has been reported a rare occurrence with other insects.

All of these laboratory tests provided a sound basis for designing and evaluating the results of a field test conducted in New York in cooperation with the New York State Conservation Department and the New York State Museum and Science Service. A series of woodlots 25 to 200 acres each were sprayed by airplane with 1/4, 1, and 2 pounds of a commercial preparation of *B. thuringiensis* (supplied by Stauffer Chemical Co.) in 2 gallons of water per acre. For one plot, a lethal quantity of polyhedra of the gypsy moth virus was added to the 1/4-pound concentration of the bacterium. Much valuable information was obtained, although no spectacular results occurred. A marked reduction in defoliation was noted, but the insect mortality effected by the highest dosage (2 pounds per acre) was lower than that considered satisfactory when using DDT. Interestingly, the addition of the virus polyhedra to the low dosage of *B. thuringiensis,* gave a degree of kill comparable to the highest dosage. Also, a very high kill of spring and fall cankerworms occurred in the treated areas — in some years these pests are as serious as the gypsy moth and similarly require direct control measures.

Perhaps necessity breeds optimism, but we feel sure we have within grasp a new control agent to use in place of or in conjunction with DDT and other synthetic insecticides.

At this early stage of research on microbial insecticides, the development of efficient and precise techniques is vital. In conjunction with the Bacteriology Department of the University of Connecticut, new and standard techniques for isolating, culturing, and identifying the bacteria found in insects are being tested. The emphasis is on techniques for anaerobic types, because the present methods of handling the aerobic spore-formers, such as the *Bacillus* group, are well standardized. What appear to be pleuropneumonia-like organisms (PPLO's) have been isolated from gypsy moth larvae, the first such isolation from an insect. A new double-staining technique was developed to show clearly at one time the vegetative cells, spores, and crystals of *Bacillus thuringiensis* and related bacterial pathogens.

At the New Haven Laboratory, more attention is being given to the insect viruses. Real progress has been made in developing histological techniques for pathological tissues. An excellent series of slides of healthy and diseased gypsy moth tissues has been prepared, using a triple stain. Color transparencies and black-and-white prints of these sections clearly show the virus polyhedra in the nuclei of infected cells in various stages of development and concentrations. Detailed tests were conducted of the serological reactions of the gypsy moth virus, using various adjuvants and special techniques to obtain higher titer antiserum. Precipitin titers as high as 1:2000 were obtained from chickens injected with the virus in a special adjuvant.

Diagnoses were made of diseased specimens of the forest tent caterpillar, elm spanworm, gypsy moth, a tussock moth, spruce budworm, cecropia and cynthia moths, and several pine sawflies collected by entomologists and other interested persons throughout the Eastern States. Virus-killed larvae of the European pine sawfly, Virginia pine sawfly, and gypsy moth were obtained in sufficient quantity to process a stock of each virus for control use in 1962.

The Nuclear Era of Science has provided a new dimension in insect control — genetic alteration of the species. The results may be lethal or sublethal, effecting death or merely failure to reproduce. Since 1957 we have investigated the feasibility of using gamma radiation to achieve this end with the gypsy moth. Here (as with the screw-worm) the aim has been to obtain sterility without crippling defects, so that treated male moths can be released in a natural population to compete with the normal males. The females do not fly, and mate just once; so a significant reduction in numbers might be obtained in one generation. Additional releases of treated males could be made as needed. Thus far, we have shown that the male gypsy moth can be made sterile without injurious side effects by

irradiating pupae 8 days old and over with 20,000 roentgens. Unanswered as yet is the question of the competitiveness and mating efficiency of treated males under natural conditions.

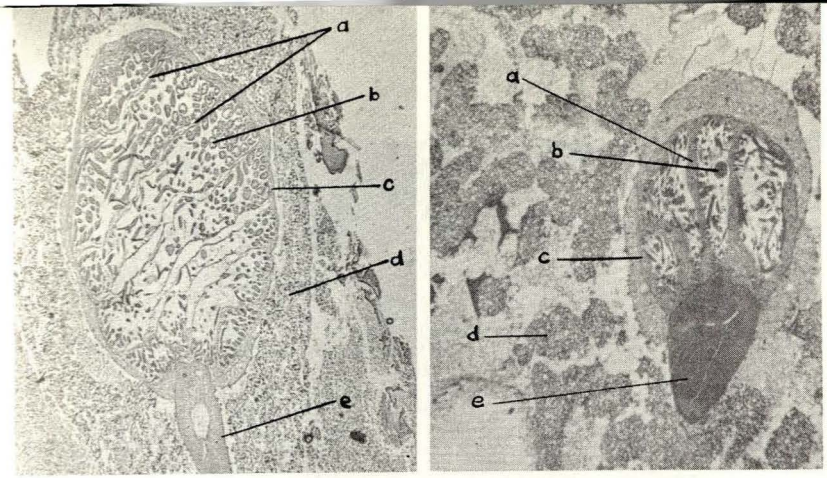
In 1961 the gamma radiation study was extended to include gypsy moth larvae. In cooperation with Brookhaven National Laboratory a replicated series of instar IV and V larvae were exposed to dosages of 500, 1,000, 2,500, 5,000, 10,000, and 20,000 roentgens. The treated insects were held in rearing to adults, or until they died, and the surviving males were mated to normal females. Being more susceptible to radiation than pupae, the larvae suffered more striking direct effects. The males were either killed or crippled by the dosages of 5,000 r and higher. Nearly all treated with 2,500 r survived, but 20 percent of these had crippling defects. No mortality or noticeable aberrations occurred in the 1,000 r and 500 r lots. Evaluation of the progeny (eggs) obtained from the successful matings has not been completed. Handling and use of larvae in this gamma radiation method is more difficult and riskier than using pupae.

In conjunction with the above experiment, a detailed study was made of spermatogenesis to determine if this vital process begins in the larval period and, if so, just how irradiation affects sperm development. Serial sections properly stained were made of the 5th abdominal segment, which contains the insect testes. The entire maturation cycle from instar I through the pupa was revealed. Spermatid formation began in instar IV, and fully developed spermatozoa were present in instar V. The process continued through the pupal stage.

The higher radiation dosages (5,000 r and up) caused distinct aberrations in most tissues observed. In the testes, the septa are enlarged and thickened, many bundles of sperm are broken down and individual sperms float free, and the vas deferens is much compacted. These and related changes do not occur in the normal testes.

The presently recommended means of preventing or controlling Dutch elm disease by removing infected trees and spraying healthy ones with DDT to kill the insect vector has proved to be a stalling action at best. Evidently the only sure way to prevent inoculation of the tree with the disease-causing fungus is to totally exclude the elm bark beetle from feeding on the delectable twigs. Douse the tree with DDT, kill most of the beetles, and infections still occur.

Another approach is to use a material that keeps the insect off the tree entirely or, more practical perhaps, one that inhibits it from feeding even though it moves about on the tree for a spell. For two years we have tested candidate chemicals for this purpose. Of 236



Microscopic section of normal untreated testis of gypsy moth. The partition-like septa (a) are relatively fine, not thickened; germarial cysts (b) are abundant and well-formed; the wall of the testis (c) is relatively thin; the fat body cells (d) are more or less evenly distributed; and the vas deferens (e) is not enlarged or thickened.

Microscopic section of testis of gypsy moth irradiated with 10,000 r as an instar IV larva. Note extreme thickening of septa (a); germarial cysts are malformed (b) or lacking; the testis wall (c) is much thickened; the fat body cells (d) are distinctly clumped; and the vas deferens (e) is enlarged and darkly colored.

screened thus far, only 4 appear really promising. Toxic effects have masked the repellent-deterrent action in some cases. The four cited will be given more thorough testing in the laboratory and then, if still seeming effective, they will be tried in the field in 1962.

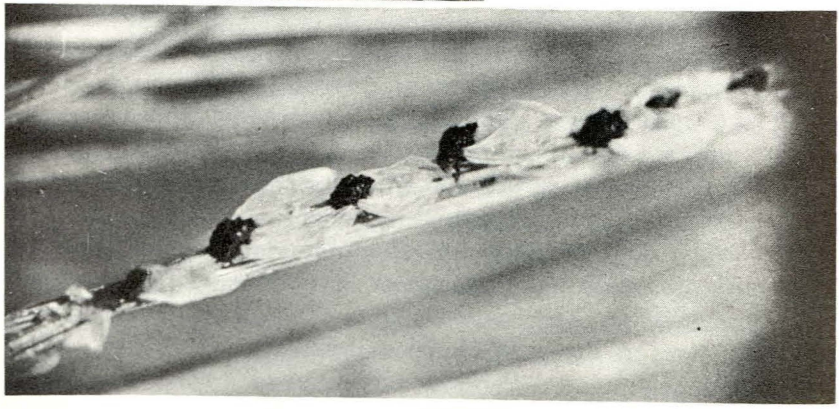
An intensive study of the pine leaf aphid, *Pineus pinifoliae* (Fitch), was begun this year. Now abundant in northern New York, Vermont, New Hampshire, and Maine, this pest has given clear evidence of its tree-killing abilities. It attacks white pine and spruce (red or black) in alternate years, causing twig mortality on the pine and galls on the spruce. Because the aphid divides its activities and damage in this manner, it has been discounted in the past as a serious threat to either white pine or spruce. But the deteriorating effects, on white pine particularly, can no longer be ignored.

This year's investigations provided new information on some biological characteristics of the insect, its intra- and inter-host distribution, and natural enemies. Detailed observations were made in two study areas in Vermont (in cooperation with the Vermont Department of Forests and Parks), with more general data taken at

Galls on red spruce, caused by the pine leaf aphid.

Pine leaf aphids newly arrived on white pine.

Aphids "tail-gating" on white pine needles.



points in New Hampshire and Maine. This is one pest that may be controllable by manipulation of the environment — that is, silvicultural practices.

The forest insect research program in 1962 also included the following projects:

Tests of the effects of a synthetic sex attractant on the behavior of male gypsy moths.

Cytological analysis of the white-pine weevil, *Pissodes strobi,* and the pine weevil *P. approximatus.*

A detailed study of survival and within-tree distribution of the red-pine scale.

Analysis of data on some temperature relations of the white-pine cone beetle.

Field and laboratory study of the gypsy moth polyhedral virus disease.

Processing virus polyhedra of different forest insects for testing or control purposes.

Release of the balsam woolly aphid predator, *Laricobius erichsonii,* at points in Maine, New Hampshire, and Vermont.

Maintenance of two outplanting series of white pine for determination of resistance to weevil attack.

Development of a cumulative damage index for control decisions on the white-pine weevil.

Laboratory tests of new insecticides and formulations against the white-pine weevil and gypsy moth.

A field test of various fluorescent materials for use as tracers in insecticidal sprays.

Forest Diseases

THE transfer from the Station to Forest Service Region 7 of a major portion of the detection and appraisal survey activities in 1961 has enabled the Station's pathologists to devote more time to forest-disease research. The balance of these surveys will be transferred as soon as conditions permit. The Station will coöperate closely with the Region in its disease surveys and control work and will continue to make observations and records on the behavior of forest tree diseases in relation to climatic and environmental conditions.

Plantation Diseases

Plots of Douglas-fir used in previous years to test the effectiveness of spray materials on leaf cast diseases were inspected in 1960 and 1961. In addition, in 1960 the antibiotics Phytoactin and Acti-dione were added to the materials tested previously. None of the materials used has given satisfactory control of *Rhabdocline pseudotsugae* or *Adelopus gäumanni* on Douglas-firs planted for Christmas trees.

Susceptibility of individual trees varies greatly, from extreme susceptibility to high resistance or almost immunity. The problem is to select strains that are resistant or immune to both diseases, and to find practical means of propagating them. A start has been made in this direction, but so far progress has been limited.

Diebacks and Declines

Foresters in the Northeast are increasingly concerned about the unexplained dying of large numbers of trees. Diebacks or declines of oak, ash, sugar maple, birch, and sweetgum have resulted in severe losses; and other species — including hickories, beech, black cherry, elm, and several conifers — are affected to a lesser degree.

Oak decline has been a leading killer of scarlet and red oaks in Pennsylvania and West Virginia. Research conducted during the past 4 years indicates that several conditions unfavorable for the oaks are involved in the disease complex. Among those factors that, acting in combination, seem to be associated with oak decline are: insect defoliation, drought, late spring freezes, attacks by the Agrilus borer, and the two fungi (*Armillaria mellea* and an unidentified fungus which may be *Dermateopsis tabacina*), that attack the roots.

Ash dieback.

Maple dieback.

Oak decline usually occurs on soils of restricted rooting depth, and damage has been most widespread during seasons having many drought days prior to mid-August.

Trees with ash dieback are characterized by thin, yellowed foliage, small leaves, suckering along the trunk, bunched and tufted leaves, and varying amounts of dieback twigs and branches. A branch canker, caused by the fungus *Cytophoma pruinosa,* is associated with the dieback. Until recently, ash dieback was thought to be confined to roadside or hedgerow trees. Now it is recognized as a serious threat to white and green ash in woodlots and forest stands. Saplings as well as older trees are affected. The disease has caused severe losses in New York and adjacent states. The major research on this disease is being conducted by pathologists of the New York State University College of Forestry at Syracuse.

Maple dieback is causing considerable damage to sugar maple throughout the Northeast, and seems to be increasing in severity. Although most serious on roadside trees, it also damages sugar bush

and forest trees. Extensive field observations and limited research indicate that this complex disease is associated with adverse growing conditions, which may vary with location. Many fungi are associated with affected trees. Some of these fungi, including *Phytophthora cactorum,* (the bleeding canker fungus) and *Verticillium albo-atrum* (maple wilt fungus), are relatively strong pathogens. Many others are either weak pathogens or saprophytes. Intensive research is needed to assess the relative importance of the many factors associated with this damaging disease.

Oak Wilt Control

The establishment of plots for evaluating the effectiveness of two different methods used in the Northeast to control oak wilt has been completed. The Station now has 68 plots testing the Pennsylvania method of control, 71 testing the West Virginia method, and 63 check plots. The behavior of oak wilt in these plots over the next several years should reveal the relative effectiveness of the control measures.

Fomes Annosus Root Rot

Research on *Fomes annosus* is one of the main projects of the Division. The following information has not been reported in previous Annual Reports.

- One series of tests has been established to determine the effectiveness of applying creosote to freshly cut stumps for preventing *Fomes annosus* infections in thinned conifer stands. Preliminary data from cooperative tests on the Harvard Forest, Petersham, Mass., indicate that creosoting freshly cut red pine stumps is effective in preventing invasion by *F. annosus.* Subsequent damage to treated stumps occurred when wood was removed from thinned stands. Injuries on treated stump surfaces should be avoided or stumps should be retreated promptly.
- Thinning stands by poisoning trees rather than cutting seems to avoid creating infection courts for *Fomes annosus.* Our tests to date indicate that stumps of trees poisoned a year earlier (have not) provided a good substrate for *F. annosus.*
- Preliminary results of cooperative tests on the Fox Forest, Hillsboro, N.H., show less invasion of stumps of trees cut when dead compared to trees cut when still alive. This substantiates preliminary conclusions from our poisoning tests, and general observations in other infected stands.

- Tabulations made in red pine on the Fox Forest in New Hampshire and in loblolly pine on the Wicomico State Forest on the Eastern Shore of Maryland show very large differences in the amounts of *Fomes annosus* present in thinned stands compared to unthinned check plots. In every case, the unthinned stands had little or no *F. annosus* infections, while the remaining trees in the thinned stands were heavily infected. This agrees with results reported in European literature as well as in Miller's report of work in New Hampshire.
- Plots were established in the fall of 1961 in loblolly pine plantations to test different thinning methods and stump treatments for preventing or reducing *F. annosus* invasion. There were five treatments: (1) creosoting freshly cut stumps; (2) applying a 20-percent urea solution to freshly cut stumps; (3) killing trees with 2,4,5-T and cutting them after at least one full growing season; (4) killing trees with 2,4,5-T, as in treatment 3, but leaving them uncut; and (5) checks consisting of untreated freshly cut stumps. Each treatment was replicated three times. Detailed examinations will be made annually until the treatments can be evaluated.
- A series of observational plots was established on the Wicomico Forest in Maryland. These are in areas thinned in 1955 in different ways. In one block every second row of trees was cut. In another block every third row was cut. In still another block every fourth row was cut. Each thinned block is 1/2 acre in size. Comparable unthinned blocks serve as checks. This work is being done in cooperation with our New Lisbon Research Center and the Maryland Department of Forests and Parks. Effect of the different thinning methods on *Fomes annosus* infection, if any, have not yet been determined.

Wood Rots and Stains

Inoculations started in 1957 to study the behavior of some of the principal rot fungi of our major tree species were continued (see 1959 Annual Report). Additional treatments were tried in 1960 and 1961. In 1960 white pine, eastern hemlock, and red and white spruce were inoculated with *Fomes pini* and *F. pinicola.* In addition, white pine was inoculated with *Polyporus anceps* and paper birch with *Fomes igniarius, F. fomentarius,* and *Poria obliqua.*

These inoculations were made on the Penobscot Experimental Forest near Bangor, Maine. Of 216 conifers selected, 162 were inoculated with one of the above fungi and the remainder will serve as

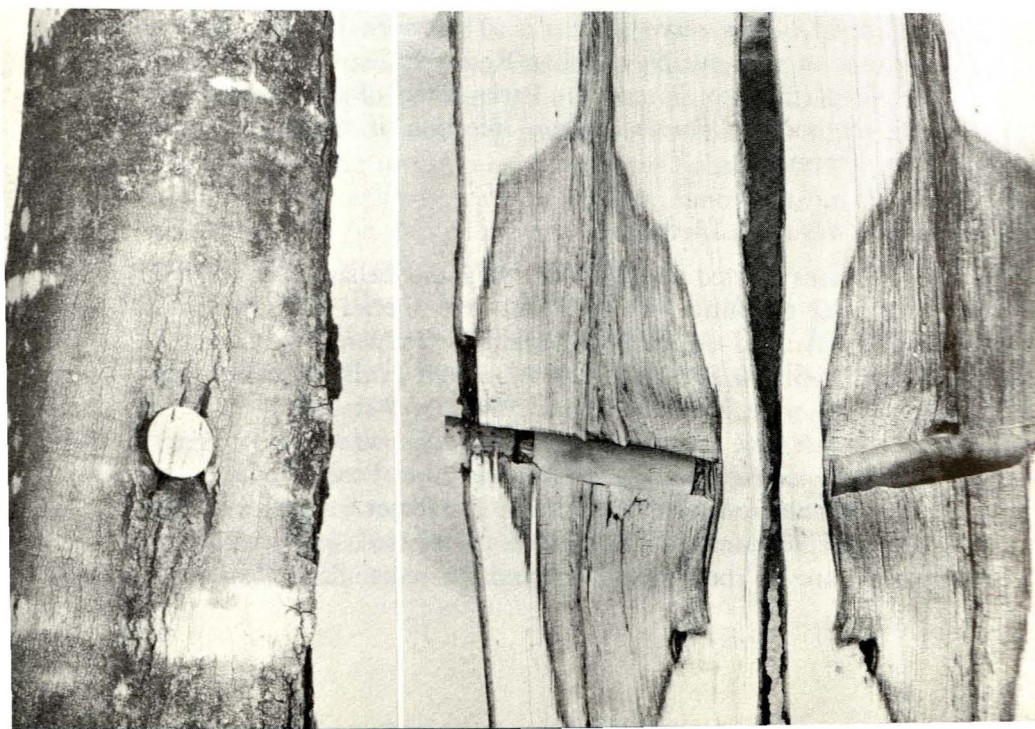
checks. Different groups of 18 paper birches were inoculated with one of the three fungi listed above. One check inoculation, with no fungus introduced, was made for every three with a fungus pathogen.

On the Cockaponset State Forest in Connecticut, 156 additional inoculations were made on hardwoods in 1961. The host trees, *Quercus montana* and *Q. borealis,* were inoculated with either *Polyporus hispidus, P. spraguei,* or *Fomes everhartii.* There were 122 fungus-inoculated and 34 check trees at this location. The method used in this work was as follows:

1. The area of the tree to be inoculated was surface-sterilized.
2. An upward-slanting hole was bored into the tree.
3. Into this hole was placed a piece of hollowed-out dowel containing a pure culture of the fungus inoculum.
4. The hole was then plugged with a sterilized cork to prevent the entrance of contaminants.

At intervals of 5, 10, and 15 years after inoculation, some of the trees will be felled and dissected. Rot extent and rot volume will be measured. Cultures will be made to verify whether the fungus used as the inoculum is present and causing decay.

Rot inoculation studies. Left, a stem inoculated with a wood-decay fungus. The cork plugging the inoculation hole prevents drying and retards contamination. Right, a stem split to show the decay developing 2 years after inoculation.

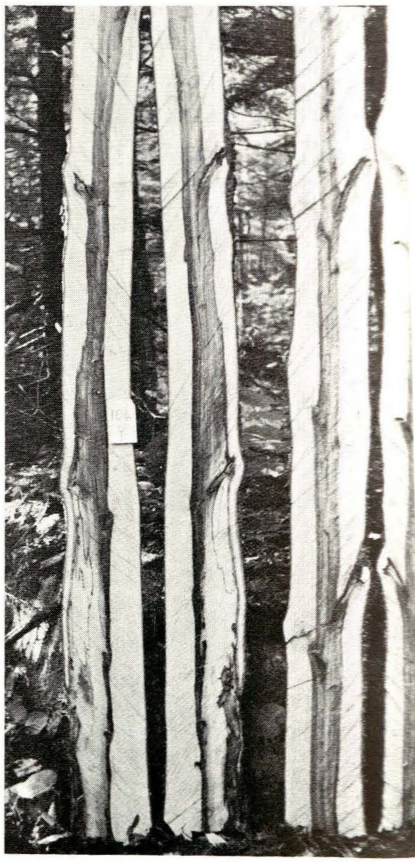


Logging-Wound Study

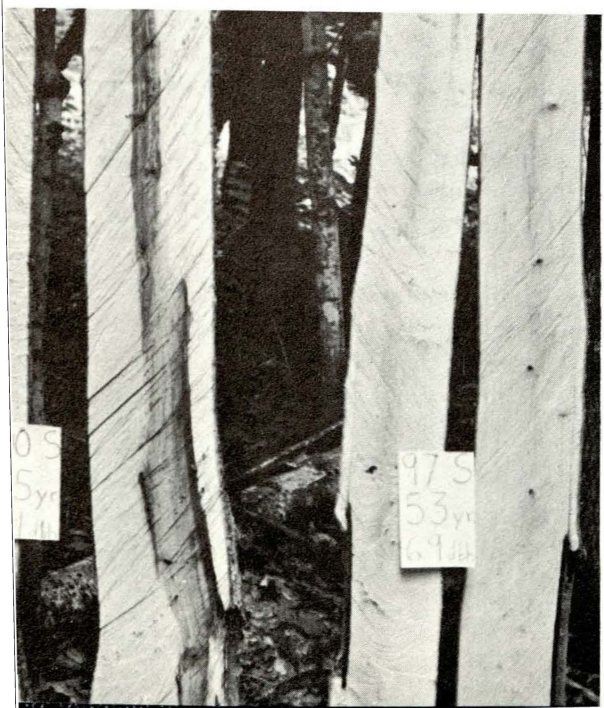
In a new study of decays and discolorations due to logging injury to northern hardwoods, 188 wounded trees in the Saco River District of the White Mountain National Forest were dissected with a one-man chain saw. Detailed data on each tree were taken and the fungi associated with the decays and discolorations were isolated in the laboratory at our Laconia Research Center. Following is a summary of the preliminary results from this study:

- The size of the wound was a poor indicator of the amount of decay and discoloration in the tree.
- The appearance of the wound face was the best indicator of decay and discoloration.
- Wounds less than 10 years old had little decay behind them.
- *Hypoxylon* spp., which caused discolorations and decay in the sapwood, appeared to be the first fungi to infect the tree through the wound. These fungi were isolated more often than all others from the wound area. Stromata of these fungi on the wound surface indicated that there was extensive decay and discoloration behind the wound.
- A *Nectria* sp. was isolated from several large 13-year-old wounds on red maple that had very little discoloration and no decay behind them.
- On older wounds, the sporophores of the following fungi were occasionally found: *Fomes connatus, F. igniarius, Polyporus versicolor,* and *Sterium* sp.
- The most frequently isolated fungi associated with discolorations were *Hypoxylon* spp., *Phialophora* spp., and *Trichocladium canadense.*
- Columns of decay were often surrounded by fungi associated with a discoloration. It appeared that the fungi causing the discoloration invaded the stem first and the decay fungi later invaded these areas.
- Since the trees were dissected longitudinally, other defects could easily be observed. Decays and discolorations around branch stubs were extensive in many trees. Although clear wood was seen over many stubs, the fungi causing the decays and discolorations were actively invading the wood.

An 8-year-old logging wound on yellow birch. The sporophores of the fungus *Polyporus versicolor* indicate extensive decay.



A yellow birch with an 8-year-old logging wound, split open to show decay. The importance of branch stubs as infection entries can also be seen here.



These two sugar maples had logging wounds of about the same size. The one on the left, when cut open, proved to have extensive decay and discoloration. But the one on the right was practically free of such defects.

Decay and Discoloration in Maple

The dissection of 240 red maple sprouts from 58 clumps has indicated that old branch stubs were more important than the parent stumps as infection courts for the fungi inciting decays and discolorations. The clumps were cut from several locations around Bartlett, N.H.

The fungi most frequently isolated, and the discoloration that they were associated with, were: *Cytospora* sp., pink discoloration; *Phialophora* spp., black-green discoloration; *Hypoxylon* spp., pink and white to a dark brown discoloration; and *Trichocladium canadense,* dark brown discoloration. The decays and discolorations did not cause much damage until after the sprouts were 50 years old.

Polyporus glomeratus was isloated frequently from sprouts in some areas, but was not present in sprouts in other areas. A *Hypoxylon* sp. was frequently isolated from the discoloration surrounding the column of decay caused by *P. glomeratus, Fomes connatus,* and several other fungi. It appeared that the decay organisms invaded the stems after the staining fungi were established.

Fungi Infecting Pulpwood Bolts

Ceratocystis virescens was found to be the principal fungus invading hardwood bolts cut for pulpwood on the Bartlett Experimental Forest. The fungus is associated with a black stain that penetrates as far as 18 inches from the end of the bolt within 6 weeks.

Decay of Wood in Use

The over-all effectiveness of ground covers as a practical means of reducing decay in subfloor timbers in houses with crawl spaces is now widely accepted by builders, maintenance men, and home owners. Current wood-moisture readings in the crawl space of the first two houses in which ground covers (55-pound and 90-pound roll roofing) were applied, in December 1942, indicate that both covers are still functioning effectively as moisture barriers.

During the past 2 years, in the Washington, D.C., area, an ill-advised maintenance practice was encountered, which greatly reduced the effectiveness of ground covers that previously had given adequate moisture-barrier protection. An overzealous salesman convinced several managers of large housing developments that, in addition to regular ground covers, a 1/2-inch thick asphalt-impregnated insulating board, installed on the underside of joists as a tight ceiling, not only would insure warm floors, but also would be an effective moisture barrier. The total effect, however, was to increase the moisture

in the subfloor timbers in most of these houses by as much as 6 percent within 6 months. In several of the houses termites were found for the first time after the insulating boards had been installed.

Chestnut Blight

More than 180 American chestnut trees, 8 inches d.b.h. or over in trunk diameter, have been included in a screening-for-blight-resistance test in the years 1954-61. About 90 percent of all the resulting American chestnut grafts have already succumbed to the blight. This suggests that for the most part the 180 native chestnut trees have been blight-escaping, rather than blight-resisting. A few of the original grafts still remain alive. These grafts, as well as the trees they represent will eventually be artificially inoculated with the fungus *Endothia parasitica* to determine if they possess a worthwhile genetical resistance to the fungus.

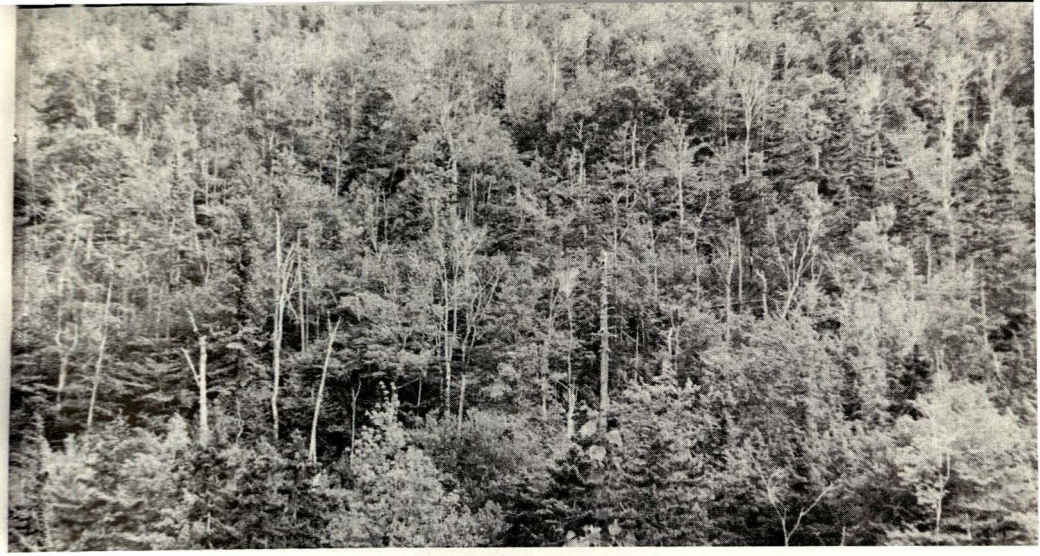
Two other current studies that have a bearing on host resistance to the chestnut blight fungus are: (1) an investigation of the possibility that a blight-resistant substance may be transferred from blight-resistant Asiatic chestnut rootstock to American chestnut grafts; and (2) a study to determine if blight resistance in chestnut can be induced by doubling the chromosome numbers. Both these studies are being conducted cooperatively with Agricultural Research Service agencies at Beltsville, Md. Tetraploidy has been induced in the American, Chinese, and Japanese species; but the resistance and the value of these new polyploid forms must still be determined.

Studies have been begun in West Virginia to detect effects of 150 and 500 ppm of Acti-dione in fuel oil sprays as a control for chestnut blight cankers. Treatments were made in August 1961 to both fungus-inoculated and uninoculated sprouts of American chestnut. Results of the tests are not yet available. Similar tests will be made of spring applications of the antibiotic.

Beech Scale-Nectria

Several fungi, including two species of *Nectria,* have been isolated from twice-stabbed ladybird beetles (*Chilocorus stigma*) collected from beech trees in the Bartlett Experimental Forest. These beetles feed on the scale (*Cryptococcus fagi*) and therefore are potential vectors for *Nectria* spp. over long distances.

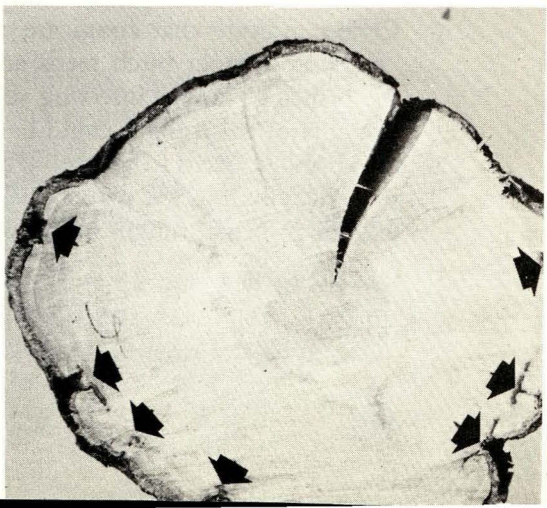
The results from laboratory experiments indicated that the mycoparasite *Gonatorrhodiella highlei* arrested sporulation of *Nectria coccinea* var. *faginata* in culture. (This mycoparasite is frequently found in nature attacking the imperfect form of the Nectria although



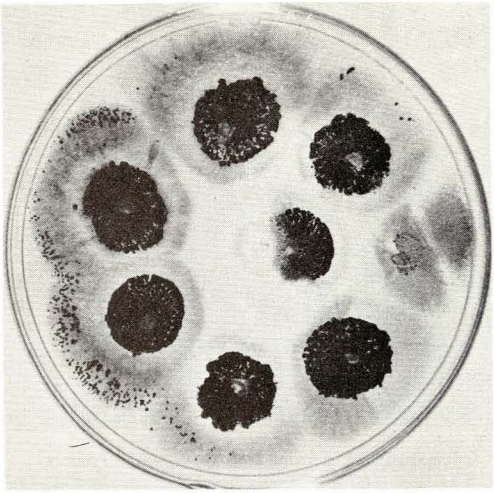
Beech killed by a severe outbreak of the beech scale-Nectria disease.

it can also be found growing over the perithecia.) The degree of parasitism was highest in those media containing a high microelement concentration. Alternating 12 hours light and darkness was best for host growth and for growth of the mycoparasite. The addition of microelements to the media also stimulated sporulation of the host under constant darkness. The experiments indicated the importance of host nutrition, and especially microelement nutrition.

Many beech trees are also attacked by another scale insect, *Xylococculus betulae.* Extreme bark roughening can result from a heavy infestation. The wounds made by these insects are sometimes infected by *Nectria* sp., but the necrotic areas are usually small and limited by callus tissue. The trees are seldom killed, but are very poor in appearance.



The arrows on this cross section of a beech log indicate areas that have been attacked by the scale insect *Xylococculus betulae.* Sometimes *Nectria* spp. infect such wounds. The lower portion of this log was killed by the fungus *Nectria coccinea* var. *faginata,* after which the killed area was invaded by secondary fungi.



Coniothyrium sp. growing from surface-sterilized yellow birch seeds placed on an agar medium. This was the principal fungus isolated from yellow birch seeds.

White Pine Blister Rust

The Pest Control Section of Region 7, in cooperation with the West Virginia Conservation Commission, drenched a number of white pine seedlings with Phytoactin at the Parsons, W.Va., forest nursery. The Station made blister rust inoculations on 148 of the treated and untreated seedlings in 1961. Results so far indicate that the white pine blister rust sporidia germinates in about equal numbers on treated and untreated seedlings. Penetration of the fungus into needles was not detected histologically. The seedlings were outplanted in the fall of 1961 and will be examined periodically for cankers.

Fungi Infecting Birch Seeds and Seedlings

The results from experiments conducted at our Laconia Research Center indicate that fungi are responsible for the death of many yellow and paper birch seeds and seedlings. *Coniothyrium* sp. was the principal fungus infecting yellow birch seeds and seedlings. The pycnidia of this fungus could be seen on the seeds that were still in the strobilus. Seeds from strobili attacked by the weevil *Apion walshii* were heavily infected with *Coniothyrium* sp. A species of *Alternaria* was the principal fungus infecting seeds and seedlings of paper birch.

Forest Economics

FOREST SURVEY

THE general objectives of the nationwide Forest Survey are to determine the facts regarding present and prospective forest-resource supplies and demands, and to develop from such facts sound technical interpretations that will provide a basis for policy and program decisions at national, state, and local levels. To discharge this responsibility requires both periodic reports on the Nation's forest situation and periodic reports to appraise the forest situation in each state, region, or other geographic area covered by the Survey.

Meeting these objectives requires the collection of basic information on forest land area and condition; quantity, quality, species, and location of standing timber; timber growth; timber mortality; productivity of forest lands; amount of timber cut; trends in timber resource supply and requirements; forest ownership; and related information that bears on balancing the timber budget of the United States. These resource facts are to be adequately analyzed and interpreted and findings published.

During the years of Forest Survey we have seen an interesting evolution of survey orientation. When the survey first began, the principal aim was one of inventory — "How much timber do we have?" This changed into the problem of determining "the balance of growth and cut." Now we are also concerned with the condition and quality of our forest stands and the prospective outlook for timber supplies in relation to prospective demands.

Resurvey Design

To provide for this new orientation, much more than an inventory of timber volume and forested area is needed. The problem of obtaining an efficient sampling design has never been simple even in consideration of earlier survey needs. But, with the additional classes of data to be collected, an overall efficient statistical design must indeed be more complex.

The sampling design that we have used is the one devised for the initial survey (double sampling — photos and field plots — with stratification) combined with a technique called "sampling with

partial replacement." We can efficiently make use of the initial survey data by remeasuring only a sample of the initial permanent plots and then establishing some new ground plots.

A great gain in sampling efficiency is obtained by this procedure of remeasuring only a sample of the permanent ground plots of the initial survey. The reason for this is that there is a correlation between the volume on a plot at the time of the initial survey and the volume on that same plot at the time of resurvey. Because of this correlation a regression equation can be obtained that permits us to adjust the volume on all the initial plots to the date of resurvey. This gain in efficiency is obvious when we compare sample sizes and related sampling precision. *Indications are that we will obtain the required accuracy of survey statistics with only about one-half the total number of plots needed in the initial survey of the 12-state area.*

The resurvey design is an efficient one. We intend to keep it flexible in order to take advantage of new and better inventory techniques as they become available.

Cooperation

Whenever possible and practicable we develop cooperative inventories with the national forests, state agencies, and private industry to prevent a duplication of effort and to increase accuracy and resource information, particularly for local areas. These cooperative inventories have been made on the national forests in New Hampshire and West Virginia and with the Maryland Department of Forests and Parks. Plans are now in progress with the Pennsylvania Department of Forests and Waters for a cooperative inventory of their lands as a part of the resurvey of Pennsylvania, starting in 1962.

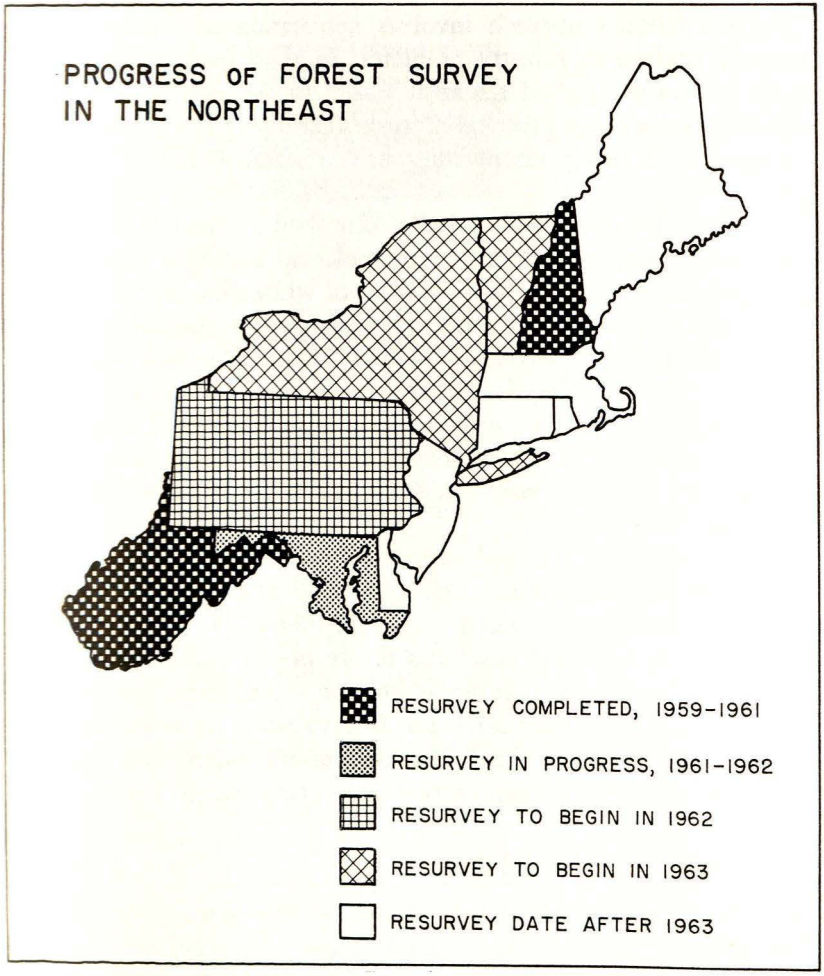
Data Processing

Another large and important aspect of the job of forest survey is to summarize the resultant data. The Northeastern and Pacific Southwest Stations have been cooperating in the preparation of a program for a large-scale electronic computer that will make the data calculations for this sampling design and produce the standard statistical tables with the associated sampling errors for each estimate in each table. A very important factor is that this electronic computer will permit us to have the resource data available only a few months after field work for a state or sampling unit has been completed.

Future Plans

The map (below) shows the status of our Forest Survey in the Northeast and a schedule for resurvey in the immediate future. Since the initial survey (1946-58), we have completed resurveys of New Hampshire and West Virginia. Reports concerning the timber resources for each of these states will be published in 1962.

We are now about half through with the field work in Maryland and well into planning for the second Pennsylvania survey. Field work in Pennsylvania will start in the spring of 1962. This will be followed by the planning stages for New York and Vermont and the start of the resurvey of these states in 1963. The remaining


PROGRESS OF FOREST SURVEY
IN THE NORTHEAST
RESURVEY COMPLETED, 1959-1961
RESURVEY IN PROGRESS, 1961-1962
RESURVEY TO BEGIN IN 1962
RESURVEY TO BEGIN IN 1963
RESURVEY DATE AFTER 1963

states of the Station's territory will be scheduled for resurvey after 1963.

The scheduling of the resurvey by selected states generally follows the completion dates of the initial survey. But we must also take into consideration other items such as the availability of new air photos, the possibilities for cooperation with state agencies and private industries, and the demands for up-to-date resource data and information.

PRODUCTION ECONOMICS AND MARKETING RESEARCH

Forest-economics research involves application of techniques of economic analysis to forestry problems. In most instances it is distinctly a form of applied research. It has to do with people, with their decisions on very practical matters. It can provide guides useful to people in choosing among alternative courses of action open to them.

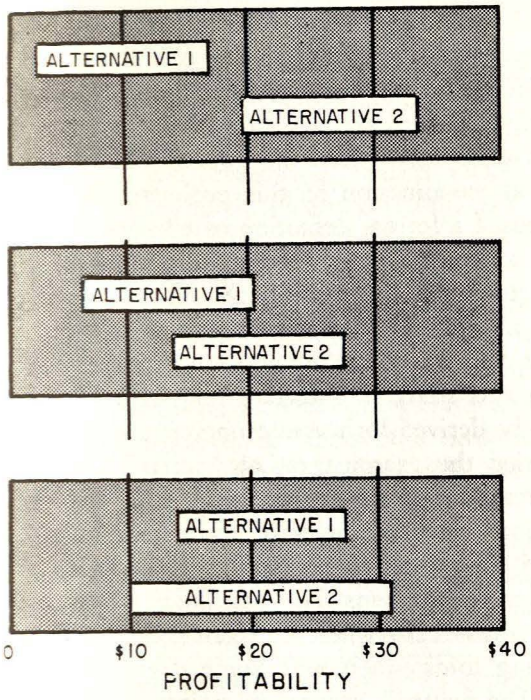
The three forest-economics studies described in our 1959 Annual Report are examples. All dealt with practical decisions facing particular groups of people. One — a study of white-pine weevil control opportunities — dealt with decisions facing pest-control agencies in the Northeast. The second — a study of timber-management opportunities in Pennsylvania — dealt with decisions facing forest-land-management agencies in Pennsylvania, notably the Department of Forests and Waters. The third — a study of blister rust control opportunities — dealt with decisions facing pest-control agencies in the Lake States.

These studies all involved organization of existing information for effective decision-making. They pulled together biological information on growth rates, effects of weevil injury, etc., and economic information on treatment costs and future prices. And they put this information into a form that would bear on a practical decision.

There are also opportunties for forest-economics research of a more fundamental kind. Work in two areas of fundamental research in forest economics has been carried out during the past year.

Uncertainty and Its Effects

The information used as a basis for decision-making in forestry is less than perfect. The benefits of forestry practices designed to hasten growth or improve timber quality are received only when



Comparing investment alternatives when uncertainty is recognized: three possibilities.

stands are harvested. There is often a long period of time between the application of forestry practices and the harvest. Events during the period can greatly alter both the biological response and the cost-and-value relationships foreseen at the time forestry practices were applied. Consequently, the results to be obtained from various forestry practices applied under various stand conditions are uncertain to one degree or another.

Two studies of the effect of uncertainty on decision-making in timber management were carried out in 1961. The first of these studies identified the nature of this uncertainty and considered its effect on the management objective usually assumed in economic analyses. These analyses usually rank timber-management opportunities in terms of expected profits; in other words, in terms of the most likely results.

This study pointed out that rational decisions can be made only after considering both the most likely results and the certainty (or uncertainty) of obtaining these particular results. Though investors are generally interested in profitability (the more the better) they may also be interested in safe, dependable profits. Suppose, for example, that the most likely results of thinning in two white pine stands

are the same (in terms of value-response per cost-dollar); but that the range of possible outcomes is much larger for one stand than for the other. Clearly, these two opportunities for thinning differ even though the most likely results are the same. An opportunity that would entice one investor might have no appeal for another.

In addition to a critical examination of this problem, the first study of uncertainty proposed a formal definition of efficient investment in forestry. Suppose a choice is to be made among investments expected to yield equal profits if the most likely results actually occur. The most efficient of these investments is the one subject to the least uncertainty. Cost data for harvesting and processing eastern white pine were used in this study to illustrate how estimates of variation in results might be derived for use in economic analyses.

The second study carried the examination of uncertainty a bit farther. It also used illustrative data for eastern white pine. It identified sources of uncertainty, gave estimates of the extent of this uncertainty, and explored the effects of uncertainty on a series of typical white pine management problems. This examination revealed that one of three situations may exist when management opportunities are compared by using information with some degree of uncertainty attaching to it. The figure illustrates the point. In the first case, one opportunity is clearly better than the other and an unambiguous decision can be reached. In the second case, although the choice is not certain, one opportunity can be judged to have the best chance of being most profitable. In the last case it is hard indeed to choose between the two alternatives on the basis of what we know about their returns.

These studies have important implications for future studies of management opportunities. They will enable us to provide more realistic guides to the decisions that managers might best make to achieve specified objectives. They strongly suggest that ranking of opportunities has two elements, not just one. *Both the most likely results and the degree of certainty of obtaining these results should be reported.*

These studies also have important implications in helping us to define more closely the role of formal economic analysis as an aid to forest managers. These studies show that formal economic analysis often cannot provide unequivocal guides to managers. However, they show that formal economic analysis can simplify the manager's job by discarding some of the alternatives that are truly inferior. And formal economic analysis can guide the manager's final judgment by disclosing key differences among the alternatives that remain.

Decision-Making Processes

But how are forestry decisions actually made? Many public programs are designed to influence the decisions of landowners, timber processors, and other groups. Their effectiveness rests on an understanding of the processes by which various kinds of decisions are actually made and the factors that influence these decisions.

A study of the processes by which firms in selected timber industries choose plant locations was undertaken (but not yet completed) during the past year. This study is designed to test a hypothesis concerning these decision-making processes. We are testing the idea that location decisions are made in stages; that profit considerations enter at one stage, personal preferences at another; and that profit considerations enter in terms of a minimum satisfactory level of profit — not maximum profit (table 3).

Table 3. — The location-decision hypothesis

Step	Objective	Considerations	Information needed
I	Recognize need for decision.	1. Low profits at present location. 2. Persistent backlog of orders. 3. Market share declining.	1. Present market conditions. 2. Projected future market conditions.
II	Select alternative locations that will earn satisfactory profits.	1. Availability of minimum satisfactory quantity of inputs. 2. Inputs available within maximum satisfactory cost level.	1. Quantity of available inputs. 2. Cost of inputs.
III	Choose alternative that best meets nonprofit objectives.	1. Satisfactory business climate. 2. Suitable living conditions.	1. History of labor relations. 2. General conditions in community.

The results of this study may be useful to development groups through the territory in appraising opportunities for expansion of timber industries. The results may also have implications in terms of other kinds of decisions. They may offer clues to the processes by which forest management decisions are made.

Progress on Other Studies

Work continues on the development of pest-control and management guides for eastern white pine in the eastern section of the country. Processing-cost and product-recovery studies, as well as pest-control and management studies, are a part of this work.

Data on the availability of wood, labor, and other factors have been assembled for selected areas in West Virginia. These data will be used in conjunction with our study of decision-making to appraise opportunities for expansion of timber industries in that state.

Other work during the year included cooperation with six agricultural experiment stations in regional marketing research; publication of a paper reporting a case study of the economics of chipping small low-quality logs; publication (with the Pennsylvania Department of Forests and Waters) of an article discussing stumpage price reporting in Pennsylvania; and publication (with our Division of Forest Management Research) of a paper reporting earnings received from two small woodland properties from the viewpoints of various types of owners.

TIMBER QUALITY

There is general agreement that there are now good opportunities for including timber-quality criteria in management decisions, both at the forest and primary-processor level. The Station has stepped up its activities to develop and test log- and tree-quality grades.

For white pine, trial log grades have been developed. In 1961 additional data were gathered in New England to complete the lumber recovery ratios for better quality logs. In his capacity as leader of the new Northern Softwood Section of the National Log Grade Project, Myron Ostrander has spearheaded tests of the trial white pine log grades in the Upper Peninsula of Michigan and in the southern Appalachians.

The Station has initiated a net volume and quality study to develop an efficient system to determine standing tree value. The trial phase of the study was conducted in West Virginia. By the end of the 1961 field season, data had been collected on 700 trees, mostly oaks and northern hardwoods. After preliminary analysis, it is likely that the study plan will be revised.

Since the original work on hardwood lumber log grades did not include black cherry, the Station has recently collaborated with NFA-Region 7 in conducting a series of black cherry grade-yield studies. Preliminary results of two such studies conducted in Pennsylvania

and West Virginia have confirmed our earlier impressions that certain modifications (with respect to adventitious buds) in the log-grade specifications will be necessary for this species. Special lumber-grading rules are already being applied to cherry lumber. Results of the log-grade studies will be published in 1962.

All our studies in the field of timber quality are carried out in cooperation with all branches of the Forest Service, within and outside the Station territory. State personnel and private industry are very helpful, too.

Forest Utilization

THE year 1961 was an important one in forest utilization and in forest-utilization research in the Northeast. Plagued by disappearing markets for such formerly staple items as low-grade softwood boards, railroad ties, mine timbers, the higher grades of hardwood lumber, paper products, wood flour, and wood for fuel, the forest-products industries of the Northeast were intensely interested in any research developments that gave promise of helping them reduce costs of production or of helping them to open up new markets for their products.

Many lumbermen invested in new and more efficient logging and sawmilling equipment to obtain greater recovery of higher grade and more accurately cut lumber, and to reduce costs. Residue-processing equipment was installed at many mills to make such products as pulp chips, charcoal, and shredded bark for mulch and chicken litter.

There was also considerable activity in remanufacture of the primary sawmill products to make them more readily salable at a higher price. This included installation of about 15 additional forced-air driers, construction or reconstruction of an even larger number of dry kilns, and establishment of several plants to make hardwood pallets and dimension stock or softwood cut stock.

The pulp and paper industry in the region made heavy expenditures for new equipment, both in its woods operations and at the mills. Two additional soda mills and one sulfite mill shifted over to the sulfate process to make chemical recovery economical, to reduce stream pollution, and to use a greater variety of species to

better advantage. Three large mills started using chips from sawmill residues as a major source of supply, and several other mills started chip purchase on a smaller scale. One mill in Maine is shifting over to storage of its entire wood supply in the form of chips. A number of woods operations that formerly were conducted for pulpwood alone have shifted to integrated methods to realize greater values for a portion of the material harvested.

At year's end a number of additional developments were in the planning stage. These included several modern new sawmills, a major installation to make end- and edge-glued clear stock from standard grade white pine lumber, two new flakeboard plants, and a number of additional hardwood dimension-stock operations.

The Division of Forest Utilization Research has been intimately involved in all of these developments, assisting equipment manufacturers, industry representatives, and industrial development agencies in working out local applications of research results and helping to plan and conduct studies to obtain new information needed.

STUDIES UNDER WAY

Timber Harvesting

Numerous observations were made on logging experience with the new four-wheel-drive, four-wheel-steer, rubber-tired skidding tractors; and help was given to several loggers in rearranging their operations to use these machines to better advantage.

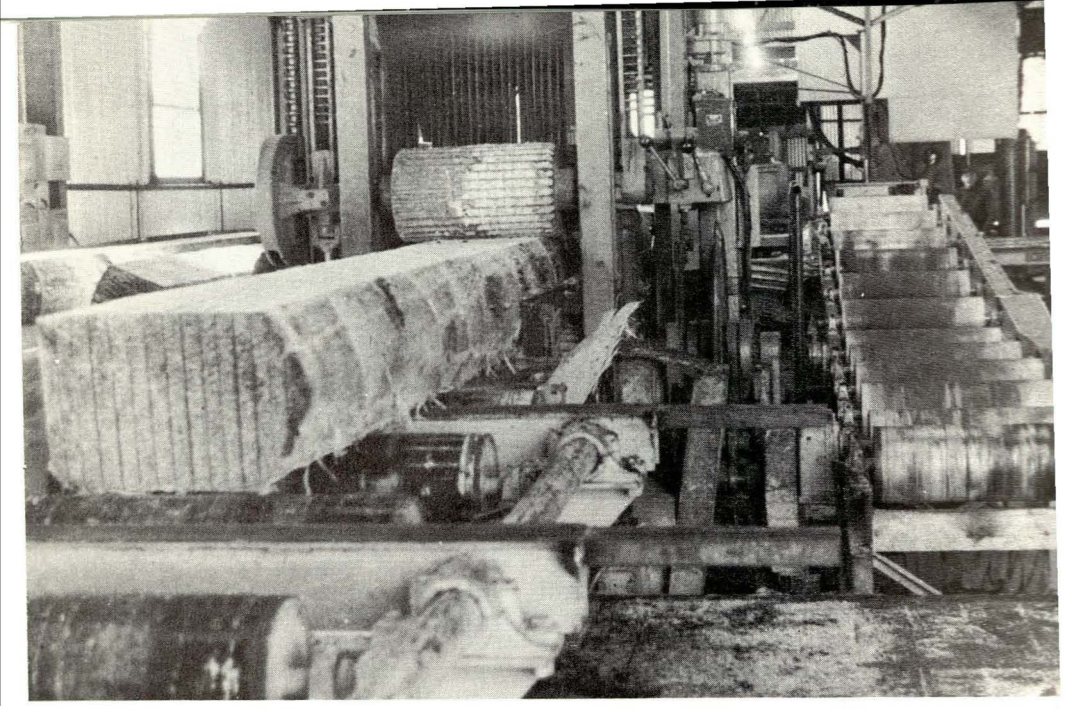
A report presented by a Station representative at the Seventh Northeastern Loggers' Congress in April told how one operator in the hills of Preston County, West Virginia, has reduced his logging costs 40 percent by purchase and use of one of these machines. Tree-length hardwoods, prebunched by a small crawler tractor, are skidded an average distance of 2½ miles, and a maximum of 4 miles, over rough woods roads directly to the sawmill. Bucking the tree lengths is done more efficiently and more intelligently at the mill yard than it could be done back in the woods.

Other operators, whose mills are remote from the timber tract, are making similar savings by skidding tree lengths to a central landing alongside an established public road. One, in the Adirondacks, contracts for tree lengths delivered at such landings, and then bucks them with a specially trained crew of mill employees. In this case the company supplies the wheel tractor, an 18,000-pound machine. Another operator, in southwestern Pennsylvania, trucks the tree lengths all the way to the mill, and bucks them with an electric chainsaw on the mill deck.

The four-wheel-drive rubber-tired tractor is making a place for itself in Northeastern logging. This one, put to work in West Virginia, skids tree-length hardwoods an average distance of 2½ miles. Its use has cut logging costs 40 percent.

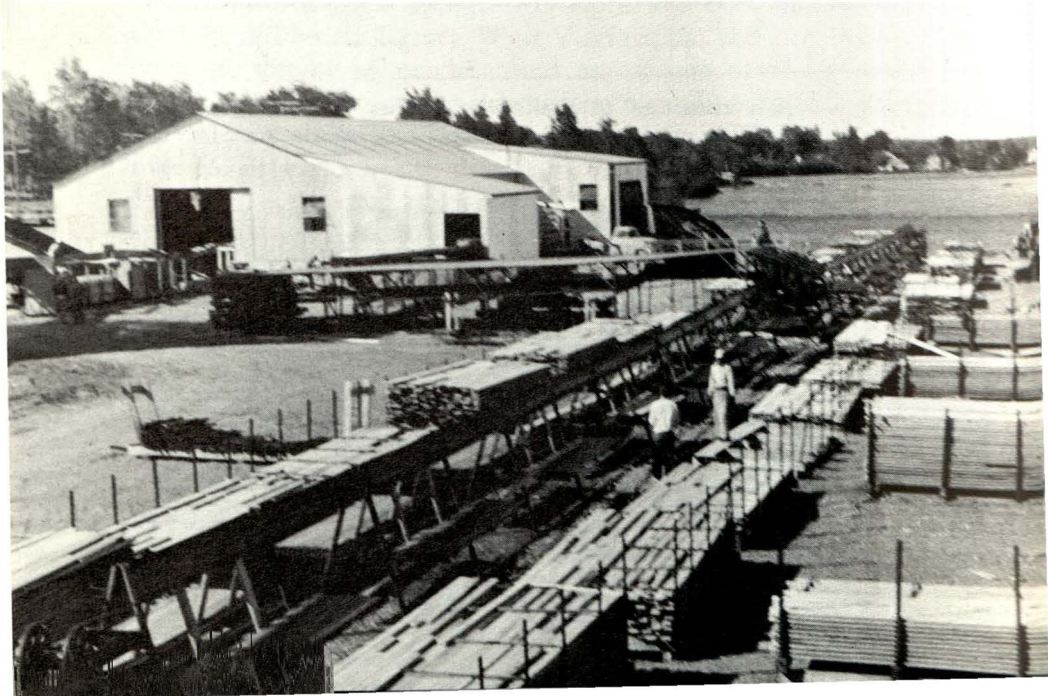
Several improved models of these rubber-tired skidding tractors have become available. Some of these have tremendously increased maneuverability because steering is done through a knuckle in the middle of the frame between the front and rear bogies, by means of hydraulic rams. One new 6,000-pound machine has a 39-inch turning radius. Improved articulation is also achieved. Any wheel can be raised or lowered as much as 20 inches in traversing rough woods trails, and still retain full power. Some of these machines have rear-mounted dozer blades to serve as anchors during tough winching jobs.

Improvements continue to make the rubber-tired tractor more useful. This machine demonstrates the articulation of its wheel system.



A number of small sawmills have installed resaws. This 30-inch sash gang resaw at a mill in Princeton, Maine, is converting a 12-inch cant into a sheaf of 4/4 lumber.

With only 14 employees, this new automated mill at Princeton, Maine, produces about 40,000 board-feet of lumber per shift, plus 50 tons of bark-free chippable residues. Semi-automatic slot lumber sorter and stacking jigs in foreground.



Observations are also being continued on the muskeg-type tractors, developed in Canada, which travel on ranks of rubber-tired idler wheels over which run tracks with spring steel grousers and rubber and nylon side members. These are proving to be excellent skidding machines, not only in deep snow and in swamps but also on muddy and rocky northeastern mountainsides. Two additional manufacturers now have machines of this type commercially available.

Data were collected and help was given on several integrated logging operations. One, being conducted on an experimental basis on a pulpmill property in eastern Maine, involves skidding tree lengths of both softwoods and hardwoods from a considerable area to a central landing. A muskeg skidder is being used for the shorter distances (less than ½ mile) and a rubber-tired machine for the more remote areas. At the landing the long lengths are bucked into sawlogs and pulpwood. A system of cost allocation on a cubic-foot basis was discussed, and criteria for the bucking job were formulated.

Small Sawmill Improvement

Similar information was collected and help given in small sawmill improvement. A number of additional mill operators installed resaws, either of the linebar or sash gang type, as the result of information supplied. Such resaws increase productivity, particularly in sawing small logs, and improve accuracy and recovery at the mill.

The number of northeastern mills that have installed pushbutton-operated carriages and varying amounts of other automatic equipment — including live log decks, pushbutton-controlled edgers and trimmers, and automatic offbearers, conveyors, and sorters — has now increased to about 150. At one completely automatic band sawmill in eastern Maine, equipped with sash gang resaw, 46,000 board-feet were sawed in an 8-hour shift with a 7-man crew. It was calculated that lumber yield has increased 14 percent at this mill, as compared to a previous installation with a circular headrig and a horizontal band resaw. Most of this increase is due to improved accuracy.

Wood Use Development

The Division cooperated in two important studies in wood use development during the year, both in conjunction with the Forest Products Laboratory. One was a study of dimension-stock yields from native hardwood lumber. A pilot study on 4/4 hard maple is being conducted by technologists from the Laboratory and from the Car-

Interest in charcoal production continues. This battery of four semi-automatic vertical charcoal retorts, at Laceyville, Pa., is being loaded with slabwood.

bondale Research Center of the Central States Station. Initially a survey was made of variability in the top five grades of hard maple lumber at 20 selected sawmills, 9 of which were in the Northeast.

Based on the results of this survey, a sample of about 20,000 board-feet of hard maple lumber is now being diagrammed in detail at the Carbondale Research Center, and the resultant data are being placed on electronic computer punch cards at the Laboratory. We expect that from this it will be possible to obtain information on yields of needed cuttings obtainable from any of the five grades for any bill of materials. During August a survey was made of users of hard maple lumber in New York, Pennsylvania, and Vermont to determine their interest in this study and ways in which the data might best be presented and used.

The other study deals with clear cuttings available in standard grade white pine produced in Maine and New Hampshire. This grade has become a drug on the market, due to the loss of most of the boxboard plants and to increasing use of plywood and composition board in place of lumber in construction. A plant has been proposed in southeastern Maine which would accumulate some 30 million feet of this No. 4 Common grade annually. The company would kiln-dry it and cut out the clear sections to be reassembled into clear face stock by gluing. To determine the practicability of this

proposal, 500 boards were graded at each of 10 typical sawmills by a crew of technologists from the Laboratory, assisted by personnel from two Station research centers. Results of this study are not yet available, but preliminary indications are that a yield of approximately 60 percent of clear material, in cuttings at least 3 inches by 12 inches in size, can be obtained. Average length of these cuttings is about 20 inches.

Additional data have been collected and help has been given at a number of plants interested or involved in making furniture parts, laminated bowling pins, hardwood pallets, parquet flooring, and a variety of other wood products.

Other Activities

In addition, Division personnel served as consultant on the programs of two new pulp and paper research laboratories, a project to determine opportunities for particle-board plants in Maine, and a number of other projects of industrial development groups, commercial research organizations, and equipment manufacturers.

We continued to be active in the affairs of the Wood Industry Division of the National Safety Council, the Equipment Committee of the Food and Agriculture Organization of the United Nations, the national, divisional, and sectional organizations of the Forest Products Research Society, The Northeastern Loggers' Association and its Utilization Division, and the New England and Keystone Kiln Drying Associations.

Publications

in 1961 by staff members and cooperators of the Northeastern Forest Experiment Station, Forest Service, U.S. Dept. of Agriculture.

General

*Bickford, C. Allen.
1961. **Stratification for Timber Cruising.**
Jour. Forestry 59: 761-763.
Proper use of stratification offers an effective means of reducing timber-cruising costs. Optimum allocation with stratification enabled Forest Survey to achieve the same accuracy with less than one-fifth of what would have been needed without stratification. Any forester interested in cutting costs should look into possible use of stratification when he cruises timber.

Bickford, C. Allen.
1961. **Elementary statistics in forest management for industrial foresters.**
Soc. Amer. Foresters New England Sect. News Quart. 22 (1): Sup., 12 pp.
Proper use of statistical methods involves five essential steps: clear statement of purpose, plan preparation, data collection, analysis of data, and interpretation of analytical results. These five steps are illustrated by using a simple application to timber cruising. Efficiency of more complex designs is shown by extension of this illustration.

*Larson, Edwin vH.
1961. **The forest wealth of Maine.**
Maine Forest Service. 29 pp., illus.
A popularized report on the findings of the forest survey of Maine, describing the history of forest use, the condition of the forest resource today, and the benefits derived from the forests, including water, recreation, and wildlife as well as pulpwood, lumber, and other wood products.

Marquis, Ralph W.
1961. **The challenge: Problems that require study and action.**
New England Sect. Soc. Amer. Foresters News Quarterly 22 (3): 45-48.
A broad view of forestry research in New England—expenditures, directions taken, the need for balance in research programs to serve the forestry management goals of the region. Adjustment may be slow, but there is optimism that shifting of research effort to fields where research now

*Copies or reprints available from the Northeastern Forest Experiment Station, U.S. Forest Service, 102 Motors Avenue, Upper Darby, Pa.

lags behind needs will come about gradually through increase in the total research effort.

Marquis, Ralph W.
1960. **Professional growth—a positive approach.**
Soc. Amer. Foresters Allegheny Sect. Proc. 1960
A summary and critique of a series of papers about the profession of forestry, from the viewpoint of those in the peripheral disciplines as well as that of the land managers. Concludes that there must be individual growth if the profession is to grow in stature, and the growth of the profession and its associations can and does aid individual growth.

Marquis, Ralph W.
1961. **Timber resources in the Northeast.**
Northeast. Logger 9 (8): 12-13, 48-49, illus.
A generalized survey of the timber reservoir in the Northeastern States, covering forest land area, timber volumes, timber quality and its importance, growth, and cut. The timber reservoir holds about 65 billion cubic feet of growing stock, a third softwoods, two-thirds hardwoods. Though the reservoir is slowly filling, it is filling with hardwoods.

Marquis, Ralph W.
1961. **Timber resources in the Northeast.**
In Forest industry opportunities in rural development, U.S. Forest Serv. Conf. Proc. 6-7, 39, illus. Harrisburg.
See above.

Marquis, Ralph W.
1961. **How shall we use our forests?**
Northeast. Logger 10 (5): 22-23, 34-35.
Discusses in broad terms the goals forest land ownership and management, and describes the U.S. Forest Service concept of multiple use of forest land: . . . by no means an assemblage of a number of single uses . . . but a deliberate and carefully planned integration of various uses that interfere with each other as little as possible and supplement each other as much as possible.

*Northeastern Forest Experiment Station.
1961. **Annual report 1960.**
Northeast. Forest Expt. Sta. 54 pp., illus.
Somewhat of a departure from our usual type of annual report, this is essentially a picture book presenting a general outline of the research programs of the Station, showing pictorially some of the work we are engaged in, results achieved, and fields that need scientific exploration. Contains an annotated list of reports published during the year.

Smith, Wendell.
1961. **Forest research in Pennsylvania.**
Pa. Forests 51: 80-83, illus.
A general history of federal forest research in Pennsylvania, which began with the establishment of the Allegheny Forest Experiment Station in Philadelphia in 1927, and is being carried on today by the Northeastern Forest Experiment Station. Describes some of the research problems programs, trends, and accomplishments.

Forest Management

*Abbott, Herschel G., and Hart, Arthur C.
1961. **Mice and voles prefer spruce seed.**
Northeast. Forest Expt. Sta., Sta. Paper 153. 12 pp., illus.
White spruce and balsam fir seed were exposed over a 5-week period in the fall in feeders designed to keep out birds and larger animals. The small mammals showed a strong preference for spruce seed, taking fir seed only when the supply of spruce seed was exhausted, which may account for the low ratio of spruce to fir seedlings under spruce-fir stands. On two 1-acre plots, red-backed voles and deer mice (49 of them, according to a live-trapping census) consumed or stored about 26 pounds of spruce seed and 1 pound of fir seed in the 5-week period.

*Allegheny Section, Society of American Foresters.
1961. **Tree planting in the Allegheny Section.**
Northeast. Forest Expt. Sta., Sta. Paper 158. 18 pp., illus.
Current planting practices are reported in terms of species used, planting dates, age of stock, spacing, plantation design, compatible plant cover, and site preparation for each of the physiographic divisions recognized by the Soil Conservation Service in each of the five states in the Allegheny Section territory. Tables list the insects and diseases that are present and that may attack each tree species in each of the physiographic sections of each state.

Barr, Carl R.
1961. **Wheel tractor skidding vs. trucking.**
Northeast. Logger 10 (2): 18, 40, illus.
An informal report on an efficient and profitable private logging operation in Preston County, West Virginia, in which the cutting practices and road layouts are based upon research results from the Fernow Experimental Forest. This operator has departed from Fernow practices by using a rubber-tired tractor for skidding tree-length logs up to 4 miles from woods to mill, thereby reducing his costs about $15 per thousand board-feet, as compared to truck hauling from a loading deck in the woods.

*Bickford, C. Allen, Longwood, Franklin R., and Bain, Robert.
1961. **Average growth rates in the spruce-fir region of New England.**
Northeast. Forest Expt. Sta., Sta. Paper 140. 23 pp.
Results from preliminary estimates of growth in Maine's spruce-fir region, based upon data from about 200 plots established in the early 1950's in a cooperative study involving 10 land-holding companies and the Station, indicate that growth considerably exceeds the rate of 1/10 to 2/10 cord per acre per year that had been widely accepted in the past. Gross growth in some stand classes approached 1 cord per acre per year. Tabular data on growth by various stand classes is presented, and procedures for estimating growth on properties comprising a number of stand classes are discussed.

*Blum, Barton M.
1961. **Age-size relationships in all-aged northern hardwoods.**
Northeast. Forest Expt. Sta. Forest Res. Note 125. 3 pp., illus.

Counts of annual rings in more than 100 stumps during cutting in an old-growth northern hardwood stand on the Bartlett Experimental Forest provided some specific data on the ranges of variation in age among trees of the same size. Tolerant species showed greater variation than intolerants. Spreads in age of as much as 91 years were observed in beech (14-inch trees), and spreads of more than 100 years occurred when all species were considered collectively.

*Burke, Hubert D.

1961. **Forest recreation research—a new undertaking by the U. S. Forest Service.**
N. Y. State Conservationist 15 (4): 27-29, illus.

A general description of the problems and tasks facing workers in recreation research, and a discussion of the recreation research program started at the Warren (Pa.) Research Center in 1959. The program will deal with both biological and engineering aspects of managing recreation areas, and with the needs and preferences of the people who use those areas. The ultimate goal is to find practical answers that recreation planners and administrators can apply.

*Davis, Grant, and Hart, Arthur C.

1961. **Effect of seedbed preparation on natural reproduction of spruce and hemlock under dense shade.**
Northeast. Forest Expt. Sta., Sta. Paper 160. 12 pp., illus.

From studies of dense softwood stands in Maine, over 4 growing seasons, the authors recommend: (1) make cuttings when soil is not snow-covered or frozen, so humus will be broken up and mixed with mineral soil; (2) log during good seed years when practicable; and (3) remove hardwoods as far as practicable to minimize accumulations of hardwood litter on newly germinated softwood seedlings.

*Eschner, Arthur R.

1960. **Observations on a hybrid poplar test planting in West Virginia.**
Northeast. Forest Expt. Sta. Forest Res. Note 111. 4 pp., illus.

A report on survival and growth of 50 hybrid poplar clones tried in test plantings in West Virginia. Seven clones appeared to do well enough to be recommended for planting under similar conditions on soils of low pH in West Virginia. These clones, all hybrids of *P. maximowiczii*, grew at an average rate of 3.6 feet per year for 9 years on a well-drained site.

*Fenton, Richard H.

1961. **Toxic effects of a fire fighting chemical.**
Jour. Forestry 59: 209-210.

One year after a fire-control demonstration of aerial drops of sodium calcium borate slurry on a compartment of the Beltsville Experimental Forest that had been cut by the seed-tree method, all the pine seed trees and much of the lesser vegetation in the drop area were dead. This points up the damage that might be done by carelessness or honest miscalculations in dropping this chemical on fires near experimental plots, seed orchards, or other high-value vegetation.

*Ford, Harold F., and Sucoff, Edward I.

1961. **Leafing-out date not indicative of growth rate in hybrid poplars.**
Northeast. Forest Expt. Sta. Forest Res. Note 123. 4 pp., illus.

Inspired by observations that certain of the fastest growing hybrid poplar clones at the Beltsville Experimental Forest also were the first to leaf out in the spring, a study was made to determine whether leafing-out date could be used as a reliable early indicator of growth rate. Early leafing-out proved to be associated with *Populus maximowiczii* parentage, and hybrids having this species as one parent also usually are fast growers. Except for this association, growth rates among the various hybrids were not correlated with leafing-out date.

*Gabriel, William J.

1961. **Rooting greenwood cuttings of yellow birch.**
Northeast. Forest Expt. Sta. Forest Res. Note 127. 3 pp.

In an exploratory study, an average of 34 percent of the cuttings from 6 yellow birch trees of varying ages struck root when treated with hormone, stuck in perlite rooting medium, and given intermittent mist under reduced light. However, after potting and storage over winter under a cover of hardwood leaves, practically all the rooted cuttings were dead by spring, demonstrating that the crucial problem with yellow birch cuttings, as with those of sugar maple, is over-winter storage.

*Gabriel, William J., Marvin, James W., and Taylor, Fred H.

1961. **Rooting greenwood cuttings of sugar maple—effect of clone and medium.**
Northeast. Forest Expt. Sta., Sta. Paper 144. 14 pp., illus.

In a study on the rooting of cuttings from 46 parent sugar maple trees in three media, with all cuttings under reduced light and intermittent mist, rooting varied among clones from 46.1 to 1.4 percent. When 11 of the same clones were re-tested the next year, rooting percentages differed considerably from their first performance; the cause of this inconsistency is obscure. Among rooting media, perlite gave the best results; sawdust was almost as good; and a mixture of moss, sand, and peat was significantly less favorable for rooting. Most of the rooted cuttings died in winter storage; the requisite conditions for successful over-winter storage remain to be discovered.

*Gershoy, A., and Gabriel, W. J.

1961. **A technique for germinating pollen of sugar maple.**
Jour. Forestry 59: 210.

In efforts to initiate germination of sugar maple pollen and prolong tube growth without premature bursting, treatments with lipase and additions of boron and calcium to the sugar agar germination medium were tested. Lengths attained by pollen tubes before bursting were substantially increased by treating the pollen grains with 0.005 percent crude lipase and adding a few crystals of boric acid to the medium.

Gilbert, Adrian M.

1961. **Comments on "Timber marking: professional procedure or subprofessional job?"**
Jour. Forestry 59: 378.

Suggests that, in timber marking, it is more important to stratify the forest by value and complexity classes than to stratify timber markers by education. Discusses objectives of timber marking.

Godden, Jack A., and Gibbs, Carter B.
1961. **Clover Run plantation.**
Northeast. Logger 10 (5): 10-11, 40-41, illus.
A description of an exceptionally fine 27-year-old plantation of white pine on a bottomland site in Tucker County, West Virginia: trees range up to 75 feet tall; volume averages 17,000 board-feet per acre. Thinning treatments carried out in 1953 and 1960, and plans for future thinnings, are described. Six permanent 1/2-acre plots representing different stocking levels were installed in 1960 for future comparisons of growth. Unfortunately *Fomes annosus* has appeared; creosote treatment of the fresh stumps is being tested as a control measure.

*Hart, Arthur C.
1961. **Thinning balsam fir thickets with soil sterilants.**
Northeast. Forest Expt. Sta., Sta. Paper 152. 8 pp., illus.
Spot applications of 3 soil sterilants—Telvar W, arsenic trioxide, and chlorea—were only partially successful in thinning a 35-year-old balsam fir thicket on the Penobscot Experimental Forest. Telvar W was the most effective chemical; at 40 or 80 pounds per acre it killed an average of 78 percent of the trees within 7-foot circles centered on the application spots.

*Hutnik, Russell J., and Cunningham, Frank E.
1961. **Silvical characteristics of paper birch.**
Northeast. Forest Expt. Sta., Sta. Paper 141. 24 pp., illus.
A discussion of the climatic, soil, physiographic, and biotic factors that govern distribution and growth of paper birch, and a description of its life history—flowering and seeding habits, capacity for vegetative reproduction, and growth characteristics and behavior from sapling stage to maturity. The discussion includes the several western and Alaskan varieties of paper birch as well as the type of variety of eastern North America.

*Hutnik, Russell J., and Yawney, Harry W.
1961. **Silvical characteristics of red maple.**
Northeast. Forest Expt. Sta., Sta. Paper 142. 18 pp., illus.
A discussion of the climatic, soil, physiographic, and biotic factors that govern distribution and growth of red maple, and a description of its life history—flowering and seeding habits, capacity for vegetative reproduction, and growth characteristics and behavior from sapling stage to maturity. Red maple is one of our most widely distributed tree species, being listed in 56 of the 106 eastern cover types recognized by the Society of American Foresters.

*Leak, William B.
1961. **Development of second-growth northern hardwoods on Bartlett Experimental Forest—A 25-year record.**
Northeast. Forest Expt. Sta., Sta. Paper 155. 8 pp., illus.
Data from 21 permanent cruise plots, established in the 1930's in un-

managed second-growth northern hardwoods and remeasured about 25 years later, showed that all stands, regardless of initial stocking, are moving toward a typical uneven-aged stand structure and predominance of tolerant species. Beech increased where stocking was most reduced in the early cuttings, and will maintain its gains for many years. Annual basal-area production has been greatest where initial stocking was lowest, but is leveling off as all stands approach full stocking.

*Leak, William B.

1961. **Yellow birch grows better in mixed-wood stands than in northern hardwood old-growth stands.**
Northeast. Forest Expt. Sta. Forest Res. Note 122. 4 pp.

An analysis of some old 8-year remeasurement data from permanent cruise plots established in the 1930's on the Bartlett Experimental Forest showed appreciably higher accretion and appreciably lower mortality of yellow birch in mixed hardwood-softwood stands than in typical northern hardwood stands. It is suggested that management measures to increase production of yellow birch should be focused particularly on mixed-wood sites.

Little, S.

1961. **Ground treatment of overstory and understory vegetation in existing stands: With special emphasis on Japanese honeysuckle.**
Pa. State Univ. Herbicide Symposium Proc.: 102-110.

For stems 3 inches and larger in diameter, treatments by basal spraying with 2,4,5-T, with ammate in cups or frills, with sodium arsenite in frills or spaced cuts, and with 2,4,5-T in frills are described. For smaller stems and shrubby vegetation, high-volume sprays and mist-blower treatments are discussed. For Japanese honeysuckle, experiments with several chemicals and treatment regimes by the New Lisbon Center are described, and some of the preliminary results. No single treatment eradicated honeysuckle; repeated sprays were required. 2,4-D was the most effective chemical; amitrol also worked fairly well.

*Little, S.

1961. **Recent results of tests in controlling Japanese honeysuckle.**
Hormolog 3 (1): 8-10, illus.

Tests of a number of chemical formulations and treatment regimes by the New Lisbon (N.J.) Center for control of Japanese honeysuckle in forest stands have not revealed any one-shot treatment that will completely eradicate this plant. Repeated annual sprayings in June for 3 years are required for 100-percent root kill, and periodic follow-up treatments then are necessary to prevent re-establishment from seed. 2,4-D and amitrole were the most effective chemicals.

*Little, S., and Mohr, J. J.

1961. **Tests of deer and rabbit repellents on planted loblolly pines in eastern Maryland.**
U.S. Forest Serv. Tree Planters' Notes 48: 17-19.

In a test of 4 repellent formulations, applied to loblolly pine seedlings by dipping and spraying just before planting in 2 successive years, efficacy

against rabbits was not determined because of a decline in the local rabbit population during those years. All treatments appreciably reduced deer damage, but some chemicals reduced seedling survival 10 to 15 percent. A commercial formulation of tetramethyl thiuram disulfide called Tat-Go is tentatively recommended; it did not injure seedlings and was as effective as the other formulations against deer.

*Little, S., and Somes, H. A.

1961. **Prescribed burning in the Pine Region of southern New Jersey and Eastern Shore, Maryland—a summary of present knowledge.**

Northeast. Forest Expt. Sta., Sta. Paper 151. 21 pp., illus.

Twenty years of research and applied experience have demonstrated that prescribed burning is a definitely useful practice in southern New Jersey in both silviculture and wildfire protection; on the Eastern Shore of Maryland fire is not generally recommended for protection purposes and has less application in silviculture. Recommendations for New Jersey are given as to seasons and periodicities for using fire in oak-pine stands, pine-lowland stands, and Atlantic white-cedar swamps. For Eastern Shore Maryland, research results to date justify only rather tentative suggestions on the use of fire in loblolly pine stands.

*McConkey, Thomas W.

1961. **Report on 1960 forest tree seed crop in New England.**

Northeast. Forest Expt. Sta. Forest Res. Note 115. 3 pp.

According to 46 reports received from foresters in 5 of the 6 New England States, the 1960 forest tree seed crop in the region would rank as medium. In general, the hardwoods produced better crops than the conifers, and better crops than in 1959; for several hardwoods the ratings were medium to heavy. Conifer crops mostly were light in both 1959 and 1960.

McQuilkin, W. E.

1961. **Silvicultural applications of herbicides: general problems and a short historical review.**

Pa. State Univ. Herbicide Symposium Proc.: 74-83.

A general lead-off paper for the section of the symposium dealing with silvicultural uses of herbicides. The early attempts to use chemicals for weed control in agriculture, the discovery and development of 2,4-D as a selective herbicide in the 1940's, and the subsequent introduction of 2,4,5-T, are briefly narrated as historical background. Silvicultural applications of herbicides are outlined for: (1) weed control in nursery beds; (2) planting-site preparation; (3) release of plantations and natural reproduction; (4) pre-harvest preparation for natural reproduction; (5) timber stand improvement in pole and sawtimber stands; (6) thinning plantations and natural thickets; and (7) utility line, roadside, and recreation area maintenance.

*McQuilkin, W. E., and Strickenberg, L. R.

1961. **Roadside brush control with 2, 4, 5-T on eastern national forests.**

Northeast. Forest Expt. Sta., Sta. Paper 148. 24 pp., illus.

On the basis of tests carried out in 1951-55, U.S. Forest Service Region 7

has changed over since 1956 from annual mowing to chemical control of roadside brush on all its national forests. Selective spraying with 2,4,5-T in oil was adopted as standard practice. Fire-control pumper units are converted as needed into power sprayers at little cost. Experience to date indicates that most roadsides will stand 5 years or longer between treatments. Costs for chemical control are averaging about 40 percent less than costs for annual mowing.

*Mills, Brooks B.

1961. **The Beddington burn stages a comeback.**

Northeast. Forest Expt. Sta. Forest Res. Note 117. 6 pp., illus.

A study of the 7,600-acre 1952 Beddington burn in southeastern Maine reveals excellent regeneration to aspen and birch, with an understory of softwoods—principally balsam fir. Of 244 milacre quadrats, 96 percent are stocked to one or more of the pioneer hardwood species, and 27 percent have softwoods present in the understory. Paper birch, present on 42 percent of the quadrats, is the most promising hardwood. Weeding to release paper birch from over-topping aspen is suggested as a desirable silvicultural treatment.

*Northeastern Forest Soils Conference.

1961. **Planting sites in the Northeast.**

Northeast. Forest Expt. Sta., Sta. Paper 157. 24 pp., illus.

The major physiographic divisions recognized by the Soil Conservation Service in the Northeast are described in terms of factors and conditions that affect tree planting; and planting guides are presented in the form of tables for each division. The tables list different site categories according to drainage, soil texture, soil depth, aspect, acidity, fertility, etc., and rate the suitability of various tree species for planting in each site category.

*Phillips, John J.

1961. **Prediction of yield in old-field sweetgum stands in southern New Jersey.**

Northeast. Forest Expt. Sta. Forest Res. Note 126. 4 pp. illus.

Volume measurements taken on 46 tenth-acre plots during a soil-site study of old-field sweetgum in southern New Jersey have been used in developing a yield table and a yield-prediction equation. Factors in the equation are site index, stand age, and basal area. A somewhat less accurate equation, making use of only site index and age, also is presented. Reliability of the equations outside the population used in their development has not been tested.

*Rushmore, Francis M.

1961. **Silvical characteristics of beech.**

Northeast. Forest Expt. Sta., Sta. Paper 161. 26 pp., illus.

A discussion of the climatic, soil, physiographic, and biotic factors that govern the distribution and growth of American beech, and a description of its life history—flowering and seeding habits, capacity for vegetative reproduction, and growth characteristics and behavior from sapling stage to maturity. The well-known and distinctive capacity of this species to sucker prolifically from the roots is discussed, but the literature gives no definitive answer on the importance of these suckers in natural stand regeneration.

Santamour, Frank S., Jr.

1961. **Anatomical criteria for early selection in poplars.**
Northeast. Forest Tree Improv. Conf. Proc. 8 (1960): 33-35.

Following up a clue discovered in England in apple rootstocks, first-year roots of 25 hybrid poplar clones were examined for anatomical characteristics that might be correlated with rate and vigor of tree growth. The percent of root diameter occupied by bark in the 1-year roots was found to be inversely correlated to a highly significant degree with height, diameter, and volume growth of the clones after 9 years in the field. Also, a highly significant positive correlation was found between percentage of the root bark occupied by fibers and growth of the clones in the field.

Santamour, Frank S. Jr., and Schreiner, Ernst J.

1961. **Juvenile variation in five white oak species.**
Univ. Pa. Morris Arboretum Bul. 12: 37-46, illus.

In a study at the Morris Arboretum of the variation appearing during the first 3 growing seasons among single-tree progenies of 5 white oak species, with each species including several (4 to 21) provenances, evidence of the existence of local ecotypes was found in *Quercus alba*, but not in *Q. prinus* or *Q. stellata*. The sampling of *Q. macrocarpa* and *Q. lyrata* was inadequate to justify any conclusions about ecotypes. The study indicates that individual tree selection offers more promise for genetic improvement in these species than ecotypic or racial selection.

Schreiner, Ernst J., and Santamour, Frank S. Jr.

1961. **Juvenile variation in five red oak species.**
Univ. Pa. Morris Arboretum Bul. 12: 65-70, illus.

A product of the Michaux Quercetum project, this report covers a study of the variation observed during 3 growing seasons among 7 single-tree progenies of *Quercus marilandica*, 24 of *Q. rubra*, 17 of *Q. velutina*, 7 of *Q. coccinea*, and 5 of *Q. falcata*. Variables considered included earliness of germination, 1-year and 3-year height, autumn coloration, and survival at various ages.

Shafer, Elwood L., Jr.

1961. **Development and evaluation of the twig-count method for measuring browse.**
Northeast. Wildlife Conf. Proc. 15 pp., Halifax, N. S.

The twig-count method of estimating weight of browse per unit area, previously little used, was further developed. Regressions of twig weights over twig numbers, by species, were calculated to enable conversion of counts into weights, and to yield data that can be analyzed statistically. In comparisons of results obtained by this method with results of weight estimation and clip-and-weigh methods, the twig-count method was as accurate as the clip-and-weigh method, and almost as fast as unanalyzable weight estimates.

*Shafer, E. L. Jr., Grisez, T. J., and Sowa, Ed.

1961. **Results of deer exclosure studies in northeastern Pennsylvania.**
Northeast. Forest Expt. Sta. Forest Res. Note 121. 7 pp., illus.

Seven-year results from 2 sets of deer exclosures in oak-maple stands dem-

onstrated again, as have other exclosure studies, than an abundant deer population may greatly reduce or completely prevent reproduction of certain tree species. In this instance, despite the presence of considerable browse in the area from a browse cutting, aspen was completely eliminated from the open check plots, and the stocking and growth of oaks, red maple, and other hardwoods were markedly reduced.

*Sucoff, Edward I.

1961. **Regenerating the last strips in strip-cuttings in Virginia pine.** Northeast. Forest Expt. Sta. Forest Res. Note 119. 6 pp., illus.

In tests of various combinations of burning and scarification to establish advance pine reproduction in the last strips to be cut in a strip-cutting in pure Virginia pine on the Beltsville Experimental Forest, all treatments substantially increased the amounts of reproduction over untreated control areas. Burning alone gave adequate seedling establishment, and was more effective than scarification in reducing understory hardwood competition. Suggested procedure is to burn in the fall of a good seed year shortly before the cones open, then harvest the overstory 1 or 2 years later.

*Sucoff, Edward I.

1961. **Effect of seedbed condition on regeneration of Virginia pine after logging.** Northeast. Forest Expt. Sta., Sta. Paper 147. 10 pp., illus.

In a study of the effects of 3 seedbed conditions upon establishment of pine reproduction after clearcutting a Virginia pine stand on the Beltsville Experimental Forest, germination and survival were substantially higher on areas disturbed by logging or where slash had been burned than on undisturbed areas. After 2 years, about 4 times as many pine seedlings were present where disturbance or fire had occurred. Best growth was on the burned areas. The results suggest that either overall burning or scarification would be effective for increasing pine reproduction after logging.

*Sucoff, Edward I.

1961. **Potassium, magnesium, and calcium deficiency symptoms of loblolly and Virginia pine seedlings.** Northeast. Forest Expt. Sta., Sta. Paper 164. 17 pp., illus.

In sand-culture experiments to determine the nutrient requirements of loblolly and Virginia pine seedlings, conducted by the Laurel Research Center in cooperation with the University of Maryland, distinctive deficiency symptoms for potassium, magnesium, and calcium developed when less than minimum requirements of these elements were supplied. The symptoms are described and illustrated. External deficiency symptoms for each element were associated with dry-weight concentrations of the element in the needles as follows: potassium — less than 0.26 percent; magnesium — less than 0.08 percent; calcium — less than 0.033 percent.

Toole, Vivian K., Toole, E. H., Hendricks, S. B., Borthwick, H. A., and Snow, A. G., Jr.

1961. **Responses of seeds of *Pinus Virginiana* to light.** Plant Physiol. 36: 285-290, illus.

In experiments on germination of Virginia pine seed, conducted coopera-

tively with the Agricultural Research Service at Beltsville, little germination occurred in darkness unless the seed were pretreated by cold storage or by red light. Germination was prompted by red and inhibited by far-red radiant energy, and these actions were immediately and repeatedly reversible. A pigment system in the seeds controls these photoreactions. In seed that had imbibed water at 5°C. for 1 day or more, excellent germination occurred after about 8 minutes' exposure to red light.

*Trimble, George R., Jr.

1961. **Managing mountain hardwoods—a ten-year appraisal.** Northeast. Forest Expt. Sta., Sta. Paper 143. 25 pp., illus.

Stand and growth data are presented for four 5-acre plots after 10 years under 4 management programs ranging from clearcutting to intensive selection management on the Fernow Experimental Forest. Second cuts had been made on 2 plots under selection management. Reproduction is abundant in all plots. Growth on the diameter-limit and selection plots ranges from 424 to 524 board-feet per acre per year with, as yet, no strong correlation with management intensity. Quality has been increased most under selection management, but attainment of stand-structure goals is not expected in less than 30 years.

*Trimble, George R. Jr., and Hart, George.

1961. **An appraisal of early reproduction after cutting in northern Appalachian hardwood stands.** Northeast. Forest Expt. Sta., Sta. Paper 162. 22 pp., illus.

Surveys of reproduction on compartments of the Fernow Experimental Forest, made before and 5 and 10 years after several intensities of cutting in sawtimber stands, have shown that reproduction of commercial species generally comes in abundantly on all sites after any method of cutting. Light selection cuttings favor reproduction of tolerant species — chiefly sugar maple; heavier cuttings are more favorable to intolerant species, but also result in higher proportions of sprout reproduction. Removal of 75 percent or more of the sawtimber volume will be followed by new stands in which about half the stems are of intolerant species.

*Wagar, J. Alan.

1961. **How to predict which vegetated areas will stand up best under "active" recreation.** Amer. Recreation Jour. 1 (7): 20-21.

A circular slide rule developed in Michigan for estimating the tolerance and durability of low vegetation to trampling is described. The design of the rule is based on regression analysis in which the independent variables are: (1) an area estimate of the percentage of grasses and woody vines in the low vegetation before trampling; (2) percentage of shade during the growing season; and (3) weight of low vegetation in the absence of trampling. Results are read in terms of weight of vegetation that will survive a given amount of trampling.

*Yawney, Harry W.

1961. **Killing cull trees with ammate crystals—a case study.** Northeast. Forest Expt. Sta. Forest Res. Note 120. 4 pp.

Ten years' experience with ammate for killing cull trees (dry crystals applied in ax notches) on the Fernow Experimental Forest have shown it to be an effective and economical silvicide. Kills of 90 percent or more are accomplished within 3 years after treatment. Costs fall in the range of 1.6 to 1.9 cents per tree-diameter inch (at breast height).

*Yawney, Harry W.

1961. **Introducing white pine into poor-site hardwood stands in West Virginia.**

Northeast. Forest Expt. Sta., Sta. Paper 154. 10 pp., illus.

Six-year results from a study on the Monongahela National Forest in which white pine was underplanted in poor-site hardwood stands have shown that cutting or deadening the overstory is essential and that the poorer sites offer the better chances for successful underplanting. Where the site index for oaks is 40 to 50, many of the pines are free to grow and thrifty; at site indexes of 50 to 60, understory shrubs and sprouts become increasingly competitive and more of the pines are suppressed. Without after-planting release treatments, the marginal site quality for introducing white pine appears to be about site index 55.

*Yelenosky, George.

1961. **Birch seeds will germinate under a water-light treatment without pre-chilling.**

Northeast. Forest Expt. Sta. Forest Res. Note 124. 5 pp., illus.

Exploratory tests with yellow birch and paper birch seeds, both fresh and after more than a year of dry storage at room temperature, demonstrated that, without stratification or any cold treatment, these seeds will germinate within 3 weeks in a free water medium under illumination. Practically no germination occurred in total darkness. Although the optimum light treatment was not determined, excellent germination was obtained under 80 foot-candles of cool-white fluorescent room light for 8 hours per day.

Watershed Management

*Hart, George.

1961. **Humus depths under cut and uncut northern hardwood forests.**

Northeast. Forest Expt. Sta. Forest Res. Note 113. 4 pp.

In a stand of high site quality, the H-layers averaged 2.35 inches deep in an area clearcut in 1939, 2.95 inches deep in an area thinned in 1937 with 40 percent of the volume removed, and 3.37 inches deep in an uncut stand. Differences were not so great in a lower-site quality stand: comparable humus depths there were 2.05, 2.27, and 2.33 inches.

*Leonard, Raymond E.

1961. **Interception of precipitation by northern hardwoods.**

Northeast. Forest Expt. Sta., Sta. Paper 159. 16 pp., illus.

A 2-year study of rainfall interception at the Hubbard Brook Experimental Forest showed that net precipitation (throughfall plus stemflow) averaged 87 percent of gross precipitation. For rainfalls during the leaf period

throughfall, in inches, was equal to 0.8984X −0.030 (where X = inches of gross storm rainfall); for the leafless period throughfall inches was equal to 0.942X −0.029. Stemflow inches was equal to 0.0563X −0.0024.

Leonard, Raymond E.

1961. **Net precipitation in a northern hardwood forest.** Jour. Geophys. Res. 66: 2417-2421, illus.

Throughfall and stemflow measurements for 2 growing seasons were related to gross storm-rainfalls by linear regressions. Net precipitation (throughout plus stemflow) was equal to 0.9547X −0.0324, where X is equal to gross storm-rainfall. For the 2 seasons, net precipitation averaged 87 percent of gross rainfall, of which 82 percent was rainfall and 5 percent was stemflow.

*Lull, Howard W., and Rushmore, Francis M.

1961. **Further observations of snow and frost in the Adirondacks.** Northeast. Forest Expt. Sta. Forest Res. Note 116. 4 pp., illus.

Snow-depth and water-content measurements in March and April 1960 were used to check procedures developed in 1959 for estimating snow-water content at maximum accumulation and snow-melt rate. Predicted and actual values were very close. During 51 days of observation, average snow depth on balsam fir branches was 2.13 inches, on red spruce 1.84, white pine 1.78, and hemlock 1.18. Measurements were also made of concrete frost depth beneath conifer crowns.

*Reigner, I. C., McQuilkin, W. E., and McNamara, E. F.

1961. **Report no. 4, forest and water research project, Delaware-Lehigh Experimental Forest.** Pa. Dept. Forests and Waters. 97 pp., illus. Harrisburg.

This fourth progress report on forest and watershed management research brings up to date results of the scrub oak conversion studies and calibration of the Dilldown watershed. A single-watershed calibration was developed, based on prediction of annual and monthly runoff from climatic variables. Daily streamflow and climatic data are tabulated for 4 water-years, 1955-58.

*Reinhart, K. G.

1961. **The problem of stones in soil-moisture measurement.** Soil Sci. Soc. Amer. Proc. 25: 268-270.

Soil-moisture measurements by gravimetric sampling can be improved by correcting for stone weight and stone moisture content. To obtain moisture volume, bulk density of stone-free material must be calculated. Correcting for stone-content helps remove the moisture-content variation due to the variation of the proportion of stones in different samples. To apply stone-free moisture contents on an areal basis requires estimation of the volume of the profile occupied by stones.

*Reinhart, K. G., Leonard, R. E., and Hart, G. E.

1961. **Automatic devices to take water samples and to raise trash screens at weirs.** Northeast. Forest Expt. Sta. Forest Res. Note 112. 7 pp., illus.

The sediment sampler and trash-screen lifter are activated by tripping devices that operate when the water level in the weir basin reaches a

predetermined height. When the sediment sampler is tripped, a hose connected to a sampling bottle drops into a flume carrying a portion of the streamflow. When the bottle is filled, its weight lifts the hose from the flume. The trash screen is removed when the head of water through the weir-notch is between 0.2 to 0.3 feet.

*Sushko, Walter C., and Reigner, Irvin G.
1961. **A city manages its forested watershed lands.**
Jour. Soil and Water Conserv. 16: 119-122, illus.
The City of Baltimore manages 17,300 acres of watershed lands, mostly forest, that surround 3 water-supply reservoirs. Water-supply protection measures include reforestation of idle land, careful location and drainage of logging roads and revegetation of steep grades following logging, and close supervision of recreation. Streamflow from 3 small experimental watersheds is being gaged to determine the effect of tree-planting on water yield.

*Trimble, G. R. Jr.
1961. **Water management. One of the multiple uses of forest land.**
Va. Tech. Forester 13:17-21.
Multiple-use management involves consideration of the water resources. Flood peaks and water supplies are affected by forest cutting practices. Water quality control involves reducing erosion from disturbed areas, and keeping eroded material out of streams; these are illustrated by recommended methods for locating and constructing logging roads.

Forest Insects

*Bean, J. L., and Waters, W. E.
1961. **Spruce budworm in eastern United States.**
U.S. Dept. Agr. Forest Pest Leaflet 58. 8 pp., illus.
Describes the damage and evidence of infestation by this important pest in the Northeastern and Lake States. The successive life stages, life history and habits, natural factors affecting its abundance, and indirect and direct means of control are given in brief fashion for quick reference.

*Dowden, Philip B.
1961. **The persistence of gypsy moth parasites in heavily sprayed areas on Cape Cod, Massachusetts.**
Jour. Econ. Ent. 54: 873-875.
Discusses possibilities of reducing or even eliminating beneficial insects, particularly entomophagous parasites, by aerial spraying of forests with DDT and other chemical insecticides. Observations in 1960 of small infestations of gypsy moth on Cape Cod gave clear evidence that not only this insect but its major natural enemies, including a polyhedral virus disease, persisted in areas sprayed two or more times since 1949.

*Dowden, Philip B.
1961. **The gypsy moth egg parasite, *Ooencyrtus kuwanai,* in southern Connecticut in 1960.**
Jour. Econ. Ent. 54: 876-878.

Field observation and laboratory rearing indicate that *Ooencyrtus kuwanai* completes 1 spring and 2 or 3 summer generations as a parasite of the gypsy moth in southern Connecticut. Parasitization has averaged 30 to 40 percent. A definite correlation is shown between size of egg cluster and percent parasitization.

*Dowden, Philip B.

1961. **Endemic populations of the spruce budworm in the Adirondacks.**
Jour. Econ. Ent. 54: 811-812.

A heavy outbreak of the budworm began in the Adirondacks in 1945 and subsided in 1948. Subsequently collections were made at regular observation points for a 10-year period. Numbers recovered were very low, but the data show clearly that the budworm persisted in the area throughout this endemic period and that 2 specific parasites of young larvae, *Apanteles fumiferanae* Vier. and *Glypta fumiferanae* (Vier.), maintained themselves during the period.

*Hastings, Arthur R., and Beroza, Morton.

1961. **Screening tests of chemical deterrents.**
Northeast. Forest Expt. Sta., Sta. Paper 156. 13 pp.

Outlines objective of finding a chemical deterrent to prevent feeding by the bark beetle *Scolytus multistriatus* Marsh, on healthy elms, and thus prevent inoculation of the Dutch elm disease pathogen. Testing procedure and method are given. Of 176 candidate chemicals, just one showed evidence of real deterrence without causing mortality. Five others gave some promise of effectiveness.

Lowe, James H. Jr.

1961. **Northeastern States.**
In Forest insect conditions in the United States, 1960: 33-35. U.S. Forest Serv., 38 pp., illus.

A general survey of the forest insect conditions in the Northeast, and notes on the current status of the spruce budworm, balsam woolly aphid, white-pine weevil, various sawflies, European pine shoot moth, Nantucket pine moth, pine leaf aphid, red-pine scale, white-pine cone beetle, forest tent caterpillar, eastern tent caterpillar, and gypsy moth.

*McIntyre, Thomas.

1961. **Effect of dieldrin in the glue line of oak plywood panels in preventing Lyctus beetle damage.**
Northeast. Forest Expt. Sta. Forest Res. Note 118. 4 pp.

Specially prepared panels of oak plywood, in which dieldrin had been incorporated in four different adhesives, were exposed to attack by Lyctus beetles. At the end of 1-year test period, there was no obvious damage to any of the plywood panels; all the beetle larvae recovered in dissection were dead, and feeding had been restricted to a fraction of an inch both laterally and in depth. Pieces of oak limbwood exposed at the same time were severely damaged and still heavily infested.

*McIntyre, T., and Dutky, S. R.

1961. **Aerial application of virus for control of a pine sawfly, *Neodiprion pratti pratti*.**
Jour. Econ. Ent. 54: 809-810.

A polyhedral virus isolated in 1954 from diseased specimens of this sawfly proved highly pathogenic in laboratory tests and limited field trials. In 1958, three units totalling 100 acres on the Beltsville Experimental Forest were sprayed by helicopter with different concentrations of polyhedra propagated from the original stock. Aggregate mortality in the larval and pupal stages was 92.9 percent. No difference in rate or degree of mortality resulted from the different treatments. No carryover effect of the disease occurred.

*McIntyre, T., Heller, R. C., and Morris, C. L.
1961. **The Virginia pine sawfly in 1960 — a special cooperative report.**
Northeast. Forest Expt. Sta. Forest Res. Note 114. 7 pp., illus.
Gives findings of cooperative aerial survey of sawfly outbreak in Maryland, Virginia, and North Carolina. A map shows the 1960 area of infestation in three defoliation categories, with a supplementary notation on the percentage of pine type along the flight lines. Another series of maps shows the trend of infestation in the three states, 1955-60.

*McIntyre, T., and St. George, R. A.
1961. **The old house borer.**
U. S. Dept. Agr. Leaflet 501. 8 pp., illus.
Gives specific information on the known distribution of this increasingly serious pest in buildings, its life cycle and habits. The various stages of the insect are described and shown pictorially. Ways of identifying infestations and effective means of eliminating them by fumigation and surface treatments are given in detail.

*Miller, William E., Hastings, Arthur R., and Wooten, John F.
1961. **European pine shoot moth.**
U. S. Dept. Agr. Forest Pest Leaflet 59. 8 pp., illus.
Lists host trees, visible evidence of infestation in different seasons of the year, and characteristic damage. The life history of the insect is given and the successive stages are described. Low winter temperatures and parasites are primary natural control factors. Cultural methods may be effective in controlling the insect and minimizing tree injury. Chemical control is difficult and expensive.

Northeastern Forest Experiment Station.
1961. **Northeastern forest pest reporter 1 (1961).**
Northeast. Forest Expt. Sta. 11 pp. (New Haven).
First issue of the year, outlines the transfer of pest control responsibilities in the Forest Service in this region from the Northeastern Station to R-7. Describes the incidence of major forest insects and diseases in the Northeastern States up to July 1 and control operations conducted prior to that time.

Northeastern Forest Experiment Station.
1961. **Northeastern forest pest reporter 2 (1961).**
Northeast. Forest Expt. Sta. 8 pp. (New Haven).
Midseason report on the status of forest pests.

Northeastern Forest Experiment Station.
1961. **Northeastern forest pest reporter 3 (1961).**
Northeast. Forest Expt. Sta. 10 pp. (New Haven).
Late-season report of forest insect and disease activity throughout the northeastern region.

Risley, John H., and Hastings, Arthur R.
1961. **White-pine weevil.**
N. Y. Conservationist. 15 (5): 12-13.
A general description of the insect and its effects on forest and plantation trees. Natural, chemical, and silvicultural control methods are discussed in turn, and specific recommendations are given for the more successful spray treatments using ground equipment.

Forest Diseases

*Brandt, Robert W.
1961. **Ash dieback in the Northeast.**
Northeast. Forest Expt. Sta., Sta. Paper 163. 8 pp., illus.
A general description of the dieback condition affecting ash trees in the Northeast and causing grave concern among foresters and forest industries. Describes history, distribution, and symptoms of the disease. Recommends that dying trees be salvaged wherever feasible.

*Diller, Jesse D.
1960. **The present status of screening the American chestnut for blight resistance.**
North. Nut Growers Assoc. Ann. Rpt. 51: 47-50.
From 1954 to 1959 nearly 150 American chestnut trees, 8 inches d.b.h. or over, were included in screening tests for possible blight resistance to the fungus *Endothia parasitica.* It is concluded that most of these trees have been "blight escaping", although a few show promise of some degree of genetical resistance.

Diller, Jesse D.
1961. **Blight resistant chestnut.**
Region 7 State Nurserymen Conf. Proc. 1961: 54-59.
(U. S. Forest Service, Region 7, Upper Darby, Pa.)
Discusses steps taken to combat the chestnut blight disease, including: (1) the search for a native blight-resistant tree; (2) the introduction of Asiatic chestnuts; (3) breeding chestnuts for disease resistance; (4) attempts to isolate the blight-resistance substances from resistant trees; and (5) doubling the number of chestnut chromosomes through applications of colchicine.

*Diller, Jesse D., and Koch, E. J.
1961. **The effects of environmental conditions on the growth of *Merulius lacrymans.***
Northeast. Forest Expt. Sta., Sta. Paper 149. 9 pp.
Describes a factorial experiment in which the development of the wood-

decay fungus was measured by percent weight loss of fungus-exposed wood blocks. Environmental factors, wood species, and substrata material influenced the rate of development of the fungus.

*Mook, Paul V., and Eno, Harold G.
1961. ***Fomes annosus*: what it is and how to recognize it.**
Northeast. Forest Expt. Sta., Sta. Paper 146. 33 pp., illus.
Tells the general forester and other interested persons how to recognize *Fomes annosus* in conifer plantations. Recognition characters of the fruiting fungus are stressed, and may be readily used by anyone not trained in mycology or pathology. A how-to-do-it booklet containing many excellent photographs.

*Shigo, Alex L.
1960. **Parasitism of *Gonatobotryum fuscum* on species of *Ceratocystis*.**
Mycologia 52: 584-598.
Gonatobotryum fuscum is shown to be a mycoparasite dependent on a living host. Its host range includes fungi of the genus *Ceratocystis* or related species of imperfect fungi. Light and temperature affected the degree of parasitism of *G. fuscum* on several hosts and it made its best growth in media containing a relatively high amount of carbon and a low amount of nitrogen. Manganese added to culture media stimulated the growth of *G. fuscum*.

Shigo, Alex L., Anderson, C. D., and Barnett, H. L.
1961. **Effects of concentration of host nutrients on parasitism of *Piptocephalis xenophila* and *P. virginiana*.**
Phytopathology 51: 616-620.
The degree of parasitism of *Piptocephalis xenophila* on *Penicillium frequentans* growing on agar media varied with the source and concentration of nitrogen and the ratio of carbon to nitrogen. Glucose and yeast extract directly affected the growth and parasitism of *Piptocephalis virginiana* on *Mortierella pusilla*. A direct relation was found between the concentration of nitrogen in the host medium and the soluble nitrogen in the fungus mycelium. Manganese affected the parasitism of the test fungi.

*Spaulding, Perley.
1961. **Foreign diseases of forest trees of the world.**
U. S. Dept. Agr. Handbook 197. 361 pp.
An annotated list of foreign diseases of trees of the world. Common names of the diseases and hosts are given where known. A section on foreign diseases potentially most dangerous to North American forests is appended.

*Staley, John M., and Lyon, Howard.
1961. **An electrical aid to pure culture isolation.**
U. S. Dept. Agr. Plant Dis. Rptr. 45 (4): 312-313, illus.
Describes and illustrates an electrical microforge devised for making soft-glass transfer needles used in isolating single spores and single hyphae of fungi in culture.

Forest Economics

*Dowdle, Barney, and Bain, Robert.
1961. **Lumber or chips?**
Northeast. Forest Expt. Sta., Sta. Paper 150. 10 pp., illus.
Reports a case study of log utilization alternatives at a medium-size Northeastern sawmill cutting principally white pine. Compares the contribution to profit and overhead to be obtained by sawing various sizes and grades of small low-quality pine logs into lumber vs. chipping them into pulp chips. Presents basic data that could be used to estimate availability of pulp chips at various chip prices.

*Mitchell, Wilfred C., and Webster, Henry H.
1961. **Ten-year earnings from two small woodlands.**
Northeast. Forest Expt. Sta., Sta. Paper 145. 31 pp., illus.
In this 10-year report on 2 small demonstration woodlots on the Fernow Experimental Forest, timber growth and cut are summarized for the decade under management, and theoretical cash returns are analyzed for 4 degrees of owner participation in the woods operations. Increases in property values accruing from management also are discussed. As stocking and timber quality are improved under management, increases in property values will flatten off, and earnings will come mainly from sale of high-grade timber.

Ostrander, Myron D.
1961. **Marketing the products of integrated operations.**
Northeast. Logger 10(1): 18-19, 26-31, illus.
A general discussion of markets for forest products in the Northeast. Opportunities for integrated logging throughout the region are shown. Emphasizes the contribution of grading as an aid to making market decisions.

*Stoltenberg, Carl H., Marty, Robert J., and Webster, Henry H.
1961. **Appraising forestry investment opportunities—the role of the investor, the forest practitioner, and the researcher.**
Amer. Foresters Proc. 1960: 82-85, illus.
This paper draws together several studies of forestry investment opportunities carried out by the Station's Division of Forest Economics Research. The authors examine interrelationships among the interests and activities of investors, practicing foresters, and researchers, indicating that each group has a distinct and necessary role to play in formulating forest-management decisions.

Webster, Henry H., Hagenstein, Perry R., and Schrey, Frank J. III.
1961. **Stumpage price reporting in Pennsylvania.**
Pa. Forests 51: 92-93.
A report on a price-reporting project begun several years ago by the Pennsylvania Forestry Association to explore possibilities for a useful system of stumpage-price reporting in Pennsylvania. Outlines factors that

should be considered if a system of price reporting were established with the kind of data now available; and discusses some questions for further research on price reporting, and the directions research in this could take.

Forest Utilization

*Longwood, Franklin R.
1961. **Puerto Rican woods.**
U.S. Dept. of Agr. Agr. Handbook 205. 98 pp., illus.
Of more than 500 tree species found in Puerto Rico, most are available in limited lumber quantities. Nevertheless many of them have more utility and value than current uses indicate. Describes 60 of the major species and their characteristics as determined by tests of specific gravity, weight per cubic foot, shrinkage, seasoning characteristics, machining characteristics, durability, and resistance to insects and diseases. Suggests uses for which these woods would be suitable.

*Simmons, Fred C.
1961. **Advantages of log barking to the sawmill operator.**
Northeast. Logger 10 (5): 14-15, 42-43, illus.
Evaluates several fringe benefits of debarking logs at small sawmills before they are sawed—greater productivity, better accuracy, and increased recovery from the logs received—as compared to sawing logs with the bark on. Concludes that installation of one of the less expensive mechanical log barkers would be a good investment for most sawmills cutting 1.5 million board-feet or more a year, whether or not this will result in an improved market for their slabs and edgings.

Simmons, Fred C.
1961. **The lumber industry in northern New England.**
Northeast. Logger 9 (11): 14-15, 62-64, illus.
A short history of the lumber industry in this area, with emphasis on recent developments and the current importance of this industry. A number of the more modern and efficient sawmills in the area are briefly described. A forecast of the future of this segment of the lumber industry is included.

Simmons, Fred C.
1961. **Grand opening of the Androscoggin chipping plant.**
Northeast. Logger 10 (6): 26, 70-71, illus.
Describes this new chipping plant, established in central Maine to supply chips from sawmill residues to a new softwood sulfate pulp mill 30 miles away. Thanks to favorable railroad rates obtained, this plant is able to economically accumulate bark-free slabs and edgings from medium to large sawmills throughout eastern and northern Maine, paying the mills (regardless of location) $4 a ton, green weight f.o.b. railroad loading points, for their residues. The chipping plant is highly efficient, utilizing a high-speed 10-knife chipper powered by a 300-hp. electric motor. It was designed to convert 20 cords an hour of slabs and edgings into acceptable pulp chips.

Simmons, Fred C.

1961. **El pequeño aserradero como empresa.**
(A small sawmill enterprise: in Spanish.) Internatl. Coop. Adm., Mexico. 74 pp., illus.

A Spanish edition of a manual previously published in English for use as a training aid in overseas cooperative programs. Covers selection of machinery, setting up, operation, and maintenance for the simpler types of sawmills. Sawmill business management and product marketing are also discussed. Appendix lists U. S. manufacturers of sawmill machinery and supplies.